EPL 82-1

ENVIRONMENTAL PHYSIOLOGY LABORATORY

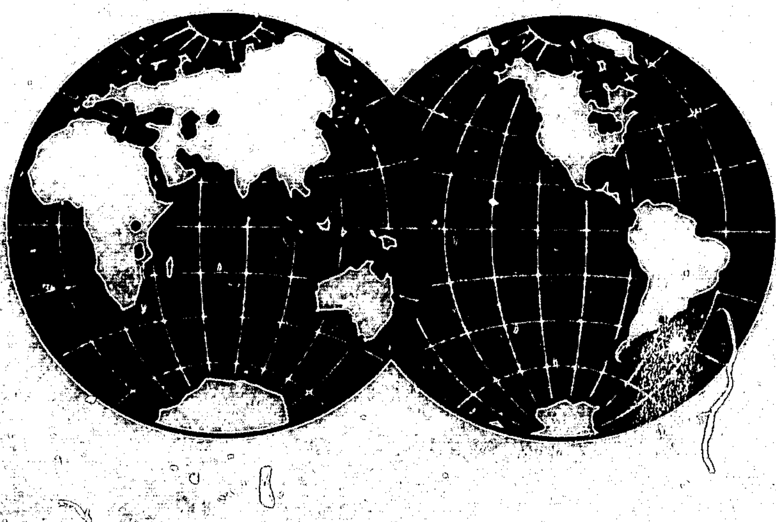
BODY COMPOSITION DATA FROM THE RAT SUBJECTS OF COSMOS 1129 EXPERIMENT K-316

(NASA-CR-168678) BODY COMPOSITION DATA FROM THE RAT SUBJECTS OF COSMOS 1129 EXPERIMENT K-316 (California Univ.) 63 p HC A04/MF A01 CSCL 06C

N82-20832

Unclas

G3/51 09357



UNIVERSITY OF CALIFORNIA - BERKELEY

EPL 82-1

ENVIRONMENTAL PHYSIOLOGY LABORATORY

UNIVERSITY OF CALIFORNIA, BERKELEY

BODY COMPOSITION DATA FROM THE RAT SUBJECTS OF COSMOS 1129 EXPERIMENT K-316

University of California, Berkeley

Nello Pace
Donald F. Rahlmann

University of California, Davis

Arthur H. Smith

University of Virginia, Charlottesville

Grover C. Pitts

Institute of Biomedical Problems, Moscow

Arkadyi S. Ushakov
Tamara A. Smirnova

Work performed under NASA Grant NSG-7336

Report prepared 15 January 1982

ABSTRACT

Cosmos 1129 Experiment K-316 was conducted jointly by USA and USSR investigators in 1979 to examine the effects of 18.5 days of weightlessness on the body composition of young, growing, male laboratory rats. Three groups of 5 rats each were examined. One group, designated Flight rats, experienced 18.5 days of Earth orbital spaceflight in the unmanned Soviet biological satellite, Cosmos 1129, before being sacrificed for dissection and biochemical analysis. A second group, designated as Synchronous Control rats, spent 18.5 days in a Cosmos spacecraft mockup on the ground under ambient conditions similar to those experienced by the Flight rats, save for spaceflight, before sacrifice for analysis. A third group, designated as Vivarium Control rats, were maintained under standard animal colony conditions before sacrifice for analysis.

The measurements made on the individual rats of each of the three groups are presented, together with statistical analyses of the data. Each rat was analyzed for major body organ masses. Water and fat contents of the 3 major body components, skin, viscera, and carcass were measured separately, and were combined to yield body water and fat contents for each rat. Body nitrogen, calcium, phosphorus, potassium, sodium, magnesium, and creatine contents were measured by direct biochemical analysis of the dried, fat-free body powder for each rat.

The results from Experiment K-316 indicate that exposure of young, growing, male rats to 18.5 days of weightlessness produces

- No effect on the quantity of fat stored by the body.
- Possibly a slight reduction in the quantity of fat-free tissue laid down by the body.

- A small, but highly significant, reduction in the fraction of water contained by the fat-free body mass.
- A similar reduction in the fraction of water contained by the fat-free skin and fat-free carcass.
- A shift in relative distribution of the total body water from skin to viscera.
- A marked diminution in the fraction of extracellular water contained by the fat-free body.
- No effect on the fraction of total skeletal musculature contained by the fat-free body, as indicated by body creatine content.
- A sizeable reduction in the fraction of bone mineral contained by the fat-free body, as calculated from body calcium content.

Many of these findings are in accord with observations made on human astronauts after experiencing prolonged periods of weightlessness. Thus, the laboratory rat can serve well as an animal model to study some aspects of the effects of the weightlessness of space flight in greater detail than is either feasible or desirable in man. Such studies, properly controlled, will be of great importance in illuminating the nature of the physiological changes induced by unloading from Earth gravity in the mammalian organism.

INTRODUCTION

The present report represents a supplementation of previous papers which describe findings from a joint 1979 USSR/USA Cosmos 1129 experiment to study the effects of weightlessness on body composition in the rat (5, 7-9). Professor Arkadyi S. Ushakov of the Institute of Biomedical Problems, USSR Ministry of Health, Moscow was primarily responsible for the design and execution of the experiment, and served as overall principal investigator. Professor Grover C. Pitts of the Department of Physiology, University of Virginia, Charlottesville, served as principal investigator for the USA component. The other investigators involved were Dr. Tamara A. Smirnova of the Institute of Biomedical Problems, Professor Nello Pace and Dr. Donald F. Rahlmann of the Environmental Physiology Laboratory, University of California, Berkeley, and Professor Arthur H. Smith of the Chronic Acceleration Laboratory, University of California, Davis.

The experiment was entitled "Effects of weightlessness on body composition in the rat", and was designated Experiment No. K-316. It involved the measurement of organ masses and biochemical composition of 5 young male rats sacrificed after spending 18.5 days in Earth orbit in the Cosmos 1129 spacecraft. The data were compared with similar measurements made on two groups of control animals. The 5 Synchronous Control rats were kept in a spacecraft mockup under ambient conditions similar to those experienced by the Flight rats, and were subjected to acceleration and noise transients similar to those that occurred during launch and reentry of Cosmos 1129. The 5 Vivarium Control rats were kept under more typical laboratory animal colony conditions.

Travel of the USA investigators to the USSR was provided through Contract NAS2-10195 between NASA and the University of Virginia. Support for the biochemical analyses carried out by the Environmental Physiology

Laboratory was provided from NASA Grant NSG-7336.

Constraints on space allowed for presentation of results in scientific journals precluded the inclusion of the individual data items for each animal studied, and only the mean values for each group of 5 rats were given in the published papers. However, the individual values are deemed to be of sufficient importance to warrant recording in the form of the present report because of the unique spaceflight opportunity represented.

EXPERIMENT CONDITIONS

At 1830 Moscow time on 25 September 1979 a Soviet biological satellite, designated Cosmos 1129, was launched into an elliptical Earth orbit from the North Cosmodrome, Plesetsk, USSR. The orbit was inclined 62.8° from the Equator with an apogee of 406 km, a perigee of 226 km, and a period of 90.5 min.

At 0800 Moscow time on 14 October 1979 Cosmos 1129 landed near the city of Kustanay in Central Asia. The payload was successfully recovered by a Soviet team within a few hours after experiencing 18.5 days of weightlessness.

Cosmos 1129 carried biological and radiation physics experiments from 9 countries, including 14 from the USA. Among the biological specimens were 30 young, growing, male Wistar specific-pathogen-free rats supplied by the Institute of Experimental Embryology of the Slovak Academy of Sciences, Bratislava, Czechoslovakia. The animals were born on 4 June 1979 ± 1 day, and were transferred to the Institute of Biomedical Problems, Moscow, on 23 August 1979 at age 80 ± 1 days. Thus, at launch on 25 September 1979 the rats were 113 ± 1 days of age, and at reentry on 14 October they were 132 ± 1 days of age.

The 30 Flight rats were arbitrarily divided into 5 groups of 5 to 7 rats in each group, and assigned to various experiments. On 10 September 1979, 15 days before launch, the rats were put in individual cages measuring

18 x 18 x 12.5 cm and placed on a special paste flight diet. Each animal received 40 grams of the diet once daily until launch. The Soviet paste diet consisted basically of 60% water and 40% of a casein-sucrose-starch-oil mixture with vitamins and minerals added. Its characteristics have been described separately in detail (4).

During the flight the rats occupied individual cylindrical chambers 20 cm in length and 10 cm in diameter. Paste diet was supplied to each animal in 10-gram lots 4 times daily at 6-hr intervals. Water was provided *ad libitum*. Each chamber was continuously ventilated with spacecraft atmosphere maintained at 22-25°C, 56-66% relative humidity, and 750-810 torr total pressure. PO_2 was 135-212 torr, PCO_2 ranged to 7 torr, with N_2 making up the rest. Lighting for each chamber at a level of 2 lux was provided from 0800 to 2000.

A group of 100 Vivarium Control animals of the same age and from the same source as the Flight animals was kept in the Institute of Biomedical Problems vivarium under similar ambient thermal and lighting conditions. However, these animals were housed 3 to a cage measuring 55 x 20 x 33 cm and received one portion of 120 grams of paste diet for all 3 animals once daily at 0900.

A group of 30 Synchronous Control animals of the same age and from the same source as the Flight and Vivarium Control rats was placed in individual cylindrical chambers in a spacecraft mockup at the Institute of Biomedical Problems on 30 September 1979, 5 days after launch of the Flight group. The animal holding units were subjected to a vibration frequency of 50-70 Hz at an amplitude of 0.4 mm and a noise level of 110 db for 10 min. Immediately after, the units were subjected to centrifugal acceleration for 10 min during which a plateau of 4 *g* was maintained for 7 min.

The Synchronous Control rats were kept in the spacecraft mockup under the same ambient thermal and lighting conditions and dietary regimen as the

Flight animals for 18.5 days until 19 October 1979. At that time, the animal holding units were subjected to centrifugal acceleration for 5 min to a 6 *g* plateau for 3 min, and then subjected to an impact shock of 50 *g* with a 10 msec duration.

Experiment K-316 was assigned a group of 5 Flight rats, designated as Group 5. The individual animals were identified as F-26, F-27, F-28, F-29 and F-30. Similarly, a group of 5 Vivarium Control rats, designated as V-26, V-27, V-28, V-29 and V-30, was assigned to Experiment K-316. Also, a group of 5 Synchronous Control rats, designed as S-26, S-27, S-28, S-29 and S-30, was assigned to Experiment K-316.

Although the Flight rats landed near Kustanay at 0800 on 14 October 1979, the K-316 Flight animals did not arrive at the Institute of Biomedical Problems in Moscow until 1600 on 15 October 1979. The animals had each received 40 grams of paste diet at 1800 on 14 October. The general condition of the animals appeared to be excellent. Animal F-26 was sacrificed for dissection at 1645 on 15 October, and the other 4 Flight animals were sacrificed at hourly intervals thereafter. Thus, the K-316 Flight rats were sacrificed 36 ± 2 hr after reentry of Cosmos 1129, and 25 ± 2 hr after the last feeding, at age 133 ± 1 days.

The K-316 Vivarium Control animals received their last feeding at 0900 on 16 October 1979, and rat V-26 was sacrificed for dissection at 1030 on 17 October 1979 with the others following at hourly intervals. Thus, the K-316 Vivarium Control rats were sacrificed 27 ± 2 hr after the last feeding at age 135 ± 1 days.

The K-316 Synchronous Control rats were removed from the spacecraft mockup on the morning of 19 October 1979, and each received 20 grams of paste diet at 1500 on that day. Animal S-26 was sacrificed for dissection at

1000 on 20 October 1979 with the others following at hourly intervals. Thus, the K-316 Synchronous Control rats were sacrificed 21 ± 2 hr after the last feeding at age 138 ± 1 days.

DISSECTION AND BIOCHEMICAL ANALYSIS PROCEDURES

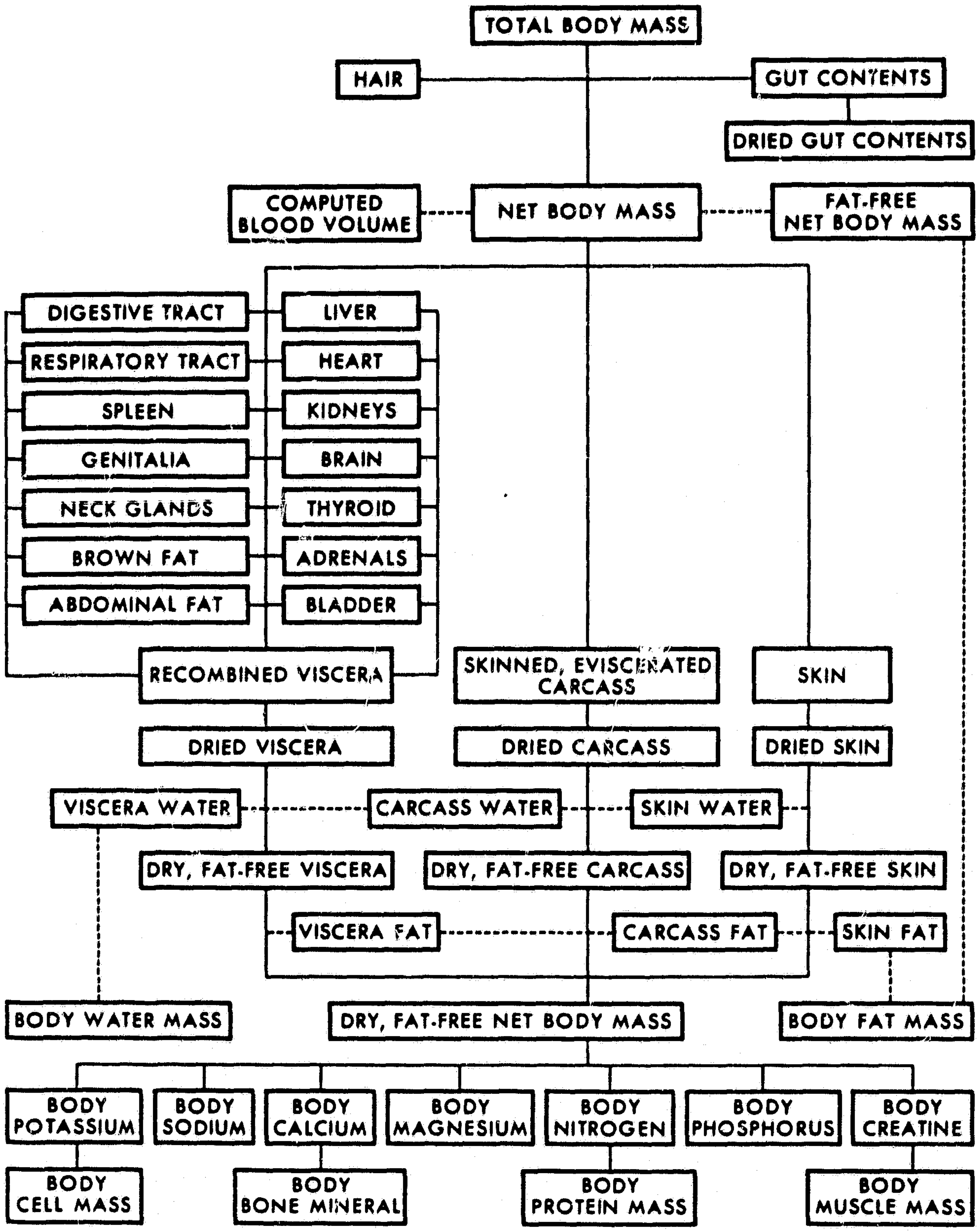
The procedures employed for the dissection and biochemical analysis performed on the K-316 rats were developed by the Environmental Physiology Laboratory under NASA Grant NSG-7336 for a study of gravitational scale effects in laboratory mammals, and have been described elsewhere in detail (3). A schema for the determinations made is shown in Fig. 1.

In essence, the animal is sacrificed by etherization and total body mass is measured. The animal is sheared and the major organ masses are determined as dissected. The organs are pooled as combined viscera, and subsequently treated as one of 3 major body components. The sheared skin and the skinned, eviscerated carcass comprise the other 2 major body components. It is worthy of note that the skinned, eviscerated carcass represents the musculoskeletal weight-bearing system of the body.

Water and fat contents of each of the 3 major components are determined by lyophilization and petroleum ether extraction, respectively. The dried, defatted residues are combined, comminuted finely, and thoroughly mixed to produce a dried, defatted body powder for each animal. Analyses of 1-gram portions of the powder are carried out for the major body elements and creatine content.

From the analytical data it is possible to derive values for a number of body composition parameters. Net body mass is obtained as mass of the total body less those of hair and of contents of the gastrointestinal tract and bladder. Body fat mass is measured as the sum of carcass, viscera and skin fat masses. Fat-free body mass is derived as the sum of carcass, viscera

FIG. 1. EPL Schema for Animal Dissection and Biochemical Analysis



ORIGINAL PAGE IS
OF POOR QUALITY

and skin fat-free masses. Body water mass is obtained as the sum of carcass, viscera and skin water masses. Dry, fat-free body mass is derived as the sum of dry, fat-free carcass, viscera and skin masses.

Body cell mass is computed as 228 times body potassium mass. Intracellular water mass is obtained as 0.73 times the body cell mass. Extracellular water mass is derived as body water mass minus intracellular water mass. Blood mass is computed as 0.07 times the net body mass. Body protein mass is estimated as 6.25 times body nitrogen mass. Bone mineral mass is computed as 2.93 times body calcium mass. Because the bulk of the body creatine is contained in skeletal muscle, the body creatine mass serves as an index of the skeletal muscle mass.

It was agreed by the USSR and USA investigators for Experiment K-316 that the animal dissections would be carried out by Dr. Donald F. Rahlmann of the Environmental Physiology Laboratory because of his extensive experience with the procedure. Accordingly, he and Professor Pitts arrived in Moscow on 11 October 1979 to prepare for the return of the Flight rats on 15 October 1979.

Staff members of the Institute of Biomedical Problems carried out the weighing procedures as the dissections progressed, and the lyophilization and petroleum ether extractions were performed by them as soon as the dissections were completed for each group of animals. As a result, the dried, defatted body powders for all 15 animals from Experiment K-316 were prepared by 27 October 1979, when Professor Pitts left Moscow for Berkeley via Tokyo with aliquots of the 15 animal powders and all the body water and fat content data. Special praise must be given to our USSR scientific collaborators for the dispatch and completeness with which the results and materials from Experiment K-316 were obtained and shared.

The 15 animal powders delivered by Professor Pitts were analyzed by the staff of the Environmental Physiology Laboratory, and the results were sent

to the Institute of Biomedical Problems for evaluation and comparison with parallel analyses performed by their personnel. The data contained in the present report include the organ mass measurements and water and fat content determinations made in Moscow, together with the biochemical analysis results obtained in Berkeley for each of the 15 rat subjects of Experiment K-316.

RESULTS

The total body masses of the 15 Experiment K-316 rats on 24 September 1979, the day before launch of Cosmos 1129, are given in column 2 of Table 1. On this date the animals were 112 ± 1 days of age. The means and standard deviations (S.D.) for the Flight group, the Synchronous Control group, and the Vivarium Control group are shown. There were no statistically significant differences between the mean total body masses of the 3 groups of 5 rats each.

The total body masses of the 5 Flight rats were determined on 14 October 1979, the day of reentry of Cosmos 1129, when the animals were 132 ± 1 days old, and are shown in column 3 of Table 1. The total body masses of the Flight rats at sacrifice for dissection the next day on 15 October 1979, when the animals were 133 ± 1 days old, are shown in column 4 of Table 1.

Inasmuch as the initiation of occupancy of the spacecraft mockup by the 5 Synchronous Control rats was offset by 5 days later than that of Cosmos 1129 by the Flight rats, the total body masses of the Synchronous Controls were not measured again until their removal from the mockup on 19 October 1979, when the animals were 137 ± 1 days old. These "postflight" values are given in column 3 of Table 1. The total body masses of the Synchronous Control rats at sacrifice for dissection the next day on 20 October 1979, when the animals were 138 ± 1 days old, are shown in column 4 of Table 1.

The total body masses of the Vivarium Control rats were measured on 16 October 1979, when the animals were 134 ± 1 days old, to provide the

"postflight" values listed in column 3 of Table 1. The total body masses of the Vivarium Control rats at sacrifice for dissection the next day on 17 October 1979, when the animals were 135 ± 1 days old, are given in column 4 of Table 1.

The independent t-test (6) was applied to the data in columns 2 and 3 of Table 1 to determine the statistical significance of the differences between preflight and postflight mean values. As shown in Table 2 all 3 groups of rats gained body mass significantly at the P <.001 level during the period of Experiment K-316. The coefficient of variation (C.V.) is also given for each mean value.

The body mass accretion in grams from preflight to postflight for the individual animals is given in column 5 of Table 1, and column 6 shows the per cent increase in preflight total body mass represented by the accretion in each case. Application of the t-test to the data in column 5 revealed that the Flight Group gained significantly less body mass than did either Control Group, and that the two Control groups did not differ significantly from each other, as indicated in Table 3.

However, a longer growth period had elapsed between the preflight and postflight measurements in the two Control groups than in the Flight group; namely, 25 days for the Synchronous Controls and 22 days for the Vivarium Controls as compared to 20 days for the Flight animals. Accordingly, the body accretion rate in grams per day was computed for each rat, and is shown in column 7 of Table 1.

Comparison of the rate of increase in total body mass among the 3 groups of rats by independent t-test is made in Table 4, where it may be seen that there was no statistically significant difference between the Flight group and the Synchronous Control group, or between the Synchronous Control group and the Vivarium Control group. On the other hand, the P value of 0.051

indicated that the Flight group verged on exhibiting a significantly lower rate of increase in total body mass than did the Vivarium Control group.

Column 8 of Table 1 lists the differences in total body mass between the postflight value and the value at sacrifice for dissection the following day. Application of the t-test revealed that all three groups of rats lost total body mass significantly in this period, as shown in Table 5. The loss in body mass is ascribable to the fact mentioned earlier that the animals received no food during the 24-hr period before sacrifice.

The individual dissected organ masses for the 5 Flight rats are listed in Table 6. Also shown are the mean, standard deviation (S.D.) and coefficient of variation (C.V.) values for each organ system. Similar data are given for the 5 Synchronous Control rats in Table 7, and for the 5 Vivarium Control animals in Table 8.

Statistical comparison of the mean values for organ masses of the Flight rats with those of the Synchronous Control rats is presented in Table 9. The mean and coefficient of variation for each group are given in columns 2 to 5. The absolute difference of the Flight mean from the Synchronous Control mean is shown in column 6, and the percentage that the difference represents from the Synchronous Control mean is listed in column 7. The probability, P, that the Flight mean is the same as the Synchronous Control mean, as computed by the independent t-test (6), is shown in column 8. The means were considered to be significantly different if the value of P was less than 0.05. Similar comparison of the mean organ masses between the Flight rats and the Vivarium Control rats appears in Table 10, and between the Synchronous Control rats and the Vivarium Control rats in Table 11.

As may be seen in Table 9, there was little difference in individual organ system masses between the Flight rats and the Synchronous Controls.

Mean spleen mass was 13% less, and mean skin mass was 12% less, in the Flight rats. Also, mean net body mass was 4% less in the Flight rats. Inasmuch as blood mass was computed directly as 0.07 x net body mass, it too was 4% less. Because of wide differences in fat content among the various organ systems, little in the way of physiologic interpretation may be made from these data. It is of interest, however, to point out that there was no significant difference in mean adrenal mass between the two groups, implying the absence of overt chronic stress response in the Flight rats relative to the Synchronous Controls.

Table 10 reveals that mean masses of liver, digestive tract, abdominal fat, and neck glands were all substantially larger for the Flight rats than for the Vivarium Control rats. As will be shown below, these differences are probably ascribable to the much higher body fat content of the Flight rats. Again, however, mean skin mass of the Flight rats was 9% less than that of the Vivarium Controls, and there was no significant difference in mean adrenal masses between the two groups.

Comparison in Table 11 between the Synchronous Control rats and the Vivarium Control rats shows similar differences among the organ systems which act as fat depots. Otherwise, there were no statistically demonstrable differences.

The water and fat contents of the 3 major body components, carcass, viscera and skin, together with the net body sums, are listed in Table 12 for each of the 5 Flight rats. Similar data are given in Table 13 for the 5 Synchronous Control rats, and in Table 14 for the 5 Vivarium Control rats.

Comparison of the mean values for each of the 3 components and for the net body as a whole between the Flight rats and the Synchronous Control rats is made in Table 15. It may be seen that there was no significant difference

in fat content of any of the 3 components, or for net body as a whole between the two groups. However, the mean fat-free body mass of the Flight rats was 6% less than that of the Synchronous Controls, and the mean fat-free skin mass was 15% less. There were no differences in mean dry fat-free masses, but both mean carcass water and mean skin water masses of the Flight rats were substantially less than those of the Synchronous Controls.

A similar comparison between the Flight rats and Vivarium Control rats is given in Table 16, and even greater differences are evident. Most strikingly, the mean fat contents of all 3 major body components were much higher in the Flight rats than in the Vivarium Controls. Furthermore, the mean fat-free masses of both carcass and skin, but not of viscera, were substantially lower in the Flight rats, resulting in a mean fat-free body mass 11% lower in the Flight rats. Both dry fat-free mass and water mass were less in the Flight rats.

The comparison between the Synchronous Control rats and the Vivarium Control rats shown in Table 17 reveals again that the mean fat contents for the Synchronous Controls were considerably greater than for the Vivarium Controls. Also, the mean fat-free body mass of the Synchronous Controls was 5% less than that of the Vivarium Controls. However, this difference was less marked than that between the Flight rats and Vivarium Controls, and involved only the carcass.

Because of the age differences in the 3 groups of growing rats at sacrifice, it is difficult to interpret the physiological significance of the absolute differences in water and fat content noted. Therefore, the fat and water contents of the 3 major body components were expressed as percentages in Tables 18-20 for the Flight rats, Synchronous Control rats, and Vivarium Control rats, respectively. Each table gives the percentage of fat in each of the 3 major body components, and in the net body as a whole. It also shows

the percentage of the total body fat contained in each of the 3 components. Each table includes the percentage of water in the fat-free mass of each of the 3 components, and in the fat-free body mass as a whole. Finally, the percentage of the total body water found in each of the 3 major body components and in the blood is given in the last section of the tables. The simplifying assumption that blood is 100% water was made in the last instance.

Table 21 exhibits the statistical comparisons of the mean fat and water percentage values between the Flight rats and the Synchronous Control rats. It may be seen that there was no significant difference in fat content or in relative body fat distribution between the two groups of animals. On the other hand, the water contents of the fat-free carcass and fat-free skin were lower in the Flight rats than in the Synchronous Controls. The differences were small but highly significant. At the same time the water content of the fat-free viscera was not significantly different in the two groups, so that the water content of the fat-free body as a whole was lower in the Flight animals. The relative body water distribution indicated a significantly greater fraction of the total body water in the viscera and a significantly lesser fraction in the skin of the Flight rats compared to the Synchronous Controls.

Comparison of the mean fat and water percentages of the Flight rats with the Vivarium Control rats is made in Table 22. It is evident that the fat content of the Flight animals was almost double that of the Vivarium Controls, with essentially the same relative distribution of fat among the 3 major body components. Once more, the water content of the Flight rats was significantly lower than that of the Vivarium Controls, and there was relatively more of the body water in the viscera and less in the skin and carcass of the Flight rats.

The mean fat and water percentage values for the Synchronous Control rats and the Vivarium Control rats are compared statistically in Table 23. The

Synchronous Controls contained 76% more fat than did the Vivarium Controls, with no differences in the relative distribution of the body fat among the 3 major body components. In contrast to the case of the Flight rats, however, there were only very slight differences in water content and relative water distribution between the Synchronous Controls and the Vivarium Controls.

Results of the analyses of the dry, fat-free body powder of each of the 5 Flight rats are given in Table 24. The parameters measured comprised nitrogen, calcium, phosphorus, potassium, sodium, magnesium, and creatine. From these analytical measurements values were derived for total body protein, body cell mass, intracellular water mass, extracellular water mass, and bone mineral mass. Similar results for the 5 Synchronous Control rats are shown in Table 25, and for the 5 Vivarium Control rats in Table 26.

Statistical comparison of the mean absolute masses of these body constituents among the 3 groups of rats is made in Tables 27-29. However, while a number of significant differences are noted, physiological interpretation of the differences is made difficult because of the age differences among the 3 groups. Therefore, the body content of the constituents was expressed as percentages of the fat-free body mass so that more meaningful comparisons could be made.

The percentage composition of the fat-free body mass of each of the 5 Flight rats is listed in Table 30. The same parameters for the 5 Synchronous Control rats are shown in Table 31, and for the 5 Vivarium rats in Table 32.

The mean percentage values for the fat-free body mass of the Flight rats are compared statistically in Table 33 with the mean values of the Synchronous Controls, where numerous significant differences in relative composition of the fat-free body mass are evident. As noted earlier from Table 21, the water content was lower for the Flight rats, so that the dry matter content

was relatively higher. Nitrogen, potassium, and creatine contents were relatively higher, while calcium and sodium contents were relatively lower in the Flight rats. The derived values indicate that body protein, body cells, and intracellular water contents were higher, and that extracellular water and bone mineral contents were lower in the Flight rats.

Qualitatively similar findings were noted when the comparison was made between the Flight rats and the Vivarium Control rats, as shown in Table 34. The only exceptions were that there were no statistically demonstrable differences in nitrogen and sodium contents between the two groups, and that magnesium content was lower in the Flight rats as compared to the Vivarium Controls.

The results were quite different when the comparison was made between the Synchronous Control rats and the Vivarium Control rats, as given in Table 35. Here only sodium content of the fat-free body mass was somewhat higher for the Synchronous Controls, and magnesium and creatine contents were lower. There were no significant differences in body protein, body cells, total water, intracellular water, extracellular water or bone mineral contents.

Table 36 shows the mass and water and dry matter composition of the contents of the digestive tract for each of the 15 rats of Experiment K-316. Statistical comparison of the mean values among the 3 groups of animals is made in Table 37. It may be seen that there were no demonstrable differences between the Flight rats and the Synchronous Control rats. However, the digestive tract of the Flight rats apparently contained more material with relatively less water than did that of the Vivarium Control rats. Although there were no statistically significant differences in composition of the digestive tract contents of the Synchronous Control rats compared to the Vivarium Control rats, it is noteworthy that in every instance the differences tended to be in the same direction as the differences between the Flight rats and the Vivarium Controls.

DISCUSSION

The theoretical design of Experiment K-316, intended to examine the effects of 18.5 days of weightlessness on the body composition of rats, was sound. The body composition of 5 rats which had flown in Earth orbit aboard Cosmos 1129 was to be determined immediately postflight by dissection and biochemical analyses. The results from the Flight rats were to be compared with analyses of a second group of 5 Synchronous Control rats of the same age, which were to have been kept under similar ambient conditions and on the same diet in a Cosmos spacecraft mockup for the same length of time as the Flight rats. Finally, both of these sets of results were to be compared with analyses of a third group of Vivarium Control rats of the same age, which were to have received the same diet but kept in standard animal colony cages.

However, at least three perturbations of the theoretical design appear to have occurred in the course of the experiment, and which must be taken into account in the interpretation of the analytical results obtained. One perturbation was an unanticipated delay in the return of the Flight rats from the Cosmos landing site near Kustanay in Central Asia to the Institute of Biomedical Problems in Moscow, where the animals were sacrificed for analysis. Thus, instead of the animals being sacrificed a few hours after return to normal Earth gravity as originally planned, they were not sacrificed until 36 ± hours after landing.

Concern that possible physiological changes which may have occurred in weightlessness might have been reversed by the time of sacrifice is mitigated by the likelihood that the time constants for body composition changes are relatively long. On this basis, the worst consequence of the delay was probably a partial abatement in magnitude of the changes induced by the weightlessness exposure. However, the qualitative pattern of the changes was most likely

not affected by the postflight delay.

A second perturbation was the lag of 5 days between the end of the Cosmos 1129 flight and the end of the Synchronous Control period. Because all the rats were of the same age at the start, this resulted in the Synchronous Control rats being 5 days older than the Flight rats at the time of sacrifice. Likewise, the Vivarium Control rats were 2 days older than the Flight rats at sacrifice.

On the day of launch all the rats were 113 ± 1 days of age, and the Flight rats were 133 ± 1 days of age at sacrifice, the Vivarium Control rats were 135 ± 1 days of age at sacrifice, and the Synchronous Control rats were 138 ± 1 days of age at sacrifice. Rats in this age range are still actively growing, and it is apparent from the data in Table 1 that in their last 5 days the Synchronous Control rats probably gained about 3.5% in total body mass. Thus, direct comparison of the body composition parameters between the Flight group and the Synchronous Control group could be misleading.

Consequently, the device was adopted of making the critical comparisons between groups on the basis of the percentage compositions rather than the absolute values. Body fat was expressed as percentage of net body mass, and the other composition parameters were expressed as percentage of fat-free body mass. The one important parameter of interest which could not be compared in this fashion was the fat-free body mass itself.

In order to estimate the magnitude of the effect of 5 days of additional growth in the Synchronous Control rats recourse was had to unpublished data from the Environmental Physiology Laboratory on the body composition of normal Simonsen Albino rats at different ages. Comparison of male rats 90 days of age with animals 150 days of age reveals that body mass growth occurred at the rate of 2.3 g/day. Of this, body fat accretion occurred at the rate of 0.9 g/day while the fat-free body mass increased at the rate of 1.4 g/day. Thus, for

this age range the body mass growth increment in male rats is 40% fat and 60% fat-free mass.

From the data in Table 1, it may be seen that the Synchronous Control rats grew at the rate of 2.49 g/day from age 112 ± 1 days to age 137 ± 1 days, and it may be estimated that in the last 5 days they added 5 x 2.49 g/day = 12.45 g of body mass. If it is assumed that 40% was fat and 60% was fat-free mass, then it may be said that the Synchronous Controls gained 4.98 g of body fat and 7.47 g of fat-free body mass during this period.

In Table 13 it may be seen that the mean fat-free body mass of the Synchronous Control rats at sacrifice was 288.35 g. Hence, 5 days earlier their fat-free body mass is estimated to have been 288.35 g - 7.47 g = 280.88 g. This value may be compared with the mean value of 271.65 g for the fat-free body mass of the Flight rats from Table 12. Thus, the mean fat-free body mass of the Flight rats was perhaps 9.2 g, or about 3.3%, less than that of the Synchronous Controls at the same age. However, the statistical validity of this approximation is indeterminate with the data available. In any case, it would appear that any difference in fat-free body mass between the Flight rats and the Synchronous Controls was small to non-existent.

A third perturbation of the theoretical design of Experiment K-316 concerns the possibility of a difference in the diet made available to the Flight rats and Synchronous Control rats on the one hand, and to the Vivarium Control rats on the other. All 3 groups of animals were to have received identical quantities of the Soviet paste diet developed for Cosmos flight experiments. However, the body composition results summarized in Tables 15-17 strongly suggest that the Vivarium Control rats received a diet different from that received by the Flight rats and the Synchronous Control rats.

A characteristic of the Soviet paste diet is that it results in a substantially higher body fat content and lower fat-free body mass in rats

of this age range when fed over the period involved in Experiment K-316. It has been shown (4) that rats receiving the Soviet paste diet contain 52% more body fat and have a 16% less fat-free body mass than do rats fed a standard rat colony diet.

From the data in Tables 16 and 17 it may be seen that the Flight rats had 90% more body fat and an 11% smaller fat-free body mass than did the Vivarium Controls. Likewise, the Synchronous Control rats had 79% more body fat and a 5% smaller fat-free body mass than did the Vivarium Controls. These marked differences in fat and fat-free masses suggest that the Vivarium Control rats may have received a diet significantly different from that received by the other two groups -- one much more like a standard rat colony diet than like the Soviet paste diet. Thus, any conclusions concerning the effects of weightlessness on body fat content and fat-free body mass should be based on comparisons between the Flight group and Synchronous Control group only.

At the same time, the study of the effects of the Soviet paste diet on body composition in the rat (4) also revealed that there was little to no difference in the fractional composition of the fat-free body mass. Hence, it seems appropriate to include the Vivarium Control rats in comparisons to establish possible effects of weightlessness on the relative composition of the fat-free body mass, as was done in Tables 33-35.

As pointed out earlier from the data shown in Table 35, there was little difference in the relative composition of the fat-free body mass between the Synchronous Control rats and the Vivarium Control rats. Relative sodium content was 4% higher and relative magnesium content was 10% lower in the Synchronous Controls, perhaps reflecting dietary differences. On the other hand, relative creatine content was 8% lower in the Synchronous Controls than in the Vivarium Controls, and this could well be indicative of a lesser skeletal muscle mass in the Synchronous Controls at the time of sacrifice.

Such a finding conforms well with the restraining influence of the small dimensions of the individual habitat chambers of the Cosmos spacecraft which the Synchronous Control rats occupied for 18.5 days prior to sacrifice.

In contrast to the rather slight differences in relative composition of the fat-free body mass of the two Control groups seen in Table 35, the Flight rats exhibited numerous divergences from the Control animals as shown in Tables 33 and 34. Furthermore, the pattern of statistically significant differences between the Flight animals and the Synchronous Controls, Table 33, is strikingly similar to the pattern of differences between the Flight rats and the Vivarium Controls, Table 34.

Relative water content of the fat-free body mass was consistently lower in the Flight animals, and the reason for this may be sought in the composition of the 3 major body components, the carcass, viscera and skin. In Table 21 it may be seen that the relative water contents of fat-free carcass and skin of the Flight rats were less than those of carcass and skin of the Synchronous Controls. It may also be seen that viscera contained a higher proportion of the body water, while skin contained a lower proportion, in the Flight animals. Similar differences in pattern of body water distribution between the Flight rats and the Vivarium Controls may be noted in Table 22.

From these results it may be concluded that the Flight rats experienced a small, but significant, net loss of body water together with a shift of body water distribution from skin to viscera. The conclusion is consistent with the hypothesis that in man in weightlessness a shift of body fluid occurs from the extremities to the upper body, together with a net loss of water from the body (2).

Another indication of an altered body fluid balance as a result of exposure to weightlessness is given by the markedly lower extracellular water

mass of the body of the Flight rats. From Tables 27 and 28 it may be seen that the mean absolute extracellular water mass of the Flight rats was 36% less than that of the Synchronous Controls and 35% less than that of the Vivarium Controls, far exceeding any possible discrepancies because of the age differences among the three groups of animals. This finding is borne out by the comparisons of relative composition of the fat-free body mass shown in Tables 33 and 34, where it may be seen that the fraction of the fat-free body mass represented by extracellular fluid was indeed substantially lower, by about 30%, in the Flight rats.

An unexpected divergence of the findings for the Flight rats in comparison to the two Control groups was in the significantly greater fraction of the fat-free body mass represented by creatine, protein, and body cells in the case of the Flight animals, as seen in Tables 33 and 34. Particularly striking was the correspondence between creatine, representing the skeletal musculature, and body cell mass as derived from body potassium measurements. The creatine fraction of the fat-free body mass of the Flight rats was 16% greater than that of the Synchronous Controls while the body cell fraction was 15% greater. Similarly, the creatine fraction of the Flight rats was 7% greater than that of the Vivarium Controls while the body cell fraction was 11% greater. Thus, it may be concluded that there was no evidence of diminution of the gross skeletal musculature in the Flight rats of Experiment K-316.

At first sight this finding would seem to be in disagreement with well-established observations of atrophic changes in certain antigravity muscles, such as the soleus, of rats after 2-3 weeks of spaceflight. However, it has also been found that the large, mixed-fiber muscles such as the quadriceps, biceps and gastrocnemius, failed to show significant weight changes (1). Thus, atrophic decreases in the mass of antigravity muscles could well be indistinguishable as a change in mass of the skeletal musculature as a whole.

The final major difference in body composition of the Flight rats from that of the two Control groups to be noted in Tables 27 and 28 was the substantially lesser body calcium content of the Flight rats, which translates as a bone mineral mass 22% less in the Flight rats than in the Synchronous Controls, and 28% less than in the Vivarium Controls. Again, these differences far exceed any possible discrepancies because of age differences among the three groups of animals, as may be seen in the comparisons of relative composition of the fat-free body mass shown in Tables 33 and 34. Bone mineral represented a 17% lower fraction of the fat-free body in the Flight rats compared to the Synchronous Controls, and a 19% lower fraction compared to the Vivarium Controls. Hence, there seems little doubt that the Flight rats of Experiment K-316 laid down considerably less bone during the 18.5 days of weightlessness than did the animals of either Control group.

In summary, the results from Experiment K-316 indicate that exposure of young, growing, male rats to 18.5 days of weightlessness produces

- No effect on the quantity of fat stored by the body.
- Possibly a slight reduction in the quantity of fat-free tissue laid down by the body.
- A small, but highly significant, reduction in the fraction of water contained by the fat-free body mass.
- A similar reduction in the fraction of water contained by the fat-free skin and fat-free carcass.
- A shift in relative distribution of the total body water from skin to viscera.
- A marked diminution in the fraction of extracellular water contained by the fat-free body.
- No effect on the fraction of total skeletal musculature contained by the fat-free body, as indicated by body creatine content.
- A sizeable reduction in the fraction of bone mineral contained by the fat-free body, as calculated from body calcium content.

Many of these findings are in accord with observations made on human astronauts after experiencing prolonged periods of weightlessness. Thus, the laboratory rat can serve well as an animal model to study some aspects of the effects of the weightlessness of space flight in greater detail than is either feasible or desirable in man. Such studies, properly controlled, will be of greater importance in illuminating the nature of the physiological changes induced by unloading from Earth gravity in the mammalian organism.

REFERENCES

(1) Castleman, K. R., L. A. Chui and J. P. Van der Meulen. Experiment K-308: Automatic analysis of muscle fibers from rats subjected to spaceflight. In: Final Reports of the U.S. Rat Experiments Flown on the Soviet Satellite Cosmos-1129. NASA Technical Memorandum 81289. M. R. Heinrich and K. A. Souza, editors. Moffett Field CA: NASA Ames Research Center, 1981, p. 267-278.

(2) Pace, N. Weightlessness: a matter of gravity. New England J. Med. 297: 32-37, 1977.

(3) Pace, N., D. F. Rahlmann and A. H. Smith. Methodology for Estimation of Total Body Composition in Laboratory Mammals. Report EPL 79-1. Berkeley: Environmental Physiology Laboratory, University of California, 1979, p. 1-41.

(4) Pace, N., D. F. Rahlmann, A. H. Smith and G. C. Pitts. Effects of the Cosmos 1129 Soviet Paste Diet on Body Composition in the Growing Rat. Report EPL 81-1. Berkeley: Environmental Physiology Laboratory, University of California, 1981, p. 1-56.

(5) Pitts, G. C., A. S. Ushakov, N. Pace, A. H. Smith, D. F. Rahlmann and T. A. Smirnova. Effects of weightlessness on body composition in the rat. Am. J. Physiol. In press, 1982.

(6) Snedecor, G. W. and W. G. Cochran. Statistical Methods. 6th edition. Ames: Iowa State University, 1967, p. 100-103.

(7) Ushakov, A. S., T. A. Smirnova, G. C. Pitts, N. Pace and A. H. Smith. K-316: Effects of weightlessness on body composition in the rat. In: Final Reports of the U.S. Rat Experiments Flown on the Soviet Satellite Cosmos-1129. NASA Technical Memorandum 81289. M. R. Heinrich and K. A. Souza, editors. Moffett Field CA: NASA Ames Research Center, 1981, p. 415-426.

(8) Ushakov, A. S., T. A. Smirnova, G. C. Pitts, N. Pace, A. H. Smith and D. F. Rahlmann. Body composition of rats flown aboard Cosmos-1129. Physiologist 23(6): S41-S44, 1980.

(9) Ushakov, A. S., T. A. Smirnova, G. C. Pitts, N. Pace, A. H. Smith and D. F. Rahlmann. Effect of the mission Cosmos-1129 on body composition in the rat. In: Advance in Physiological Sciences, Volume 19, Gravitational Physiology. J. Hideg and O. Gazenko, editors. New York: Pergamon, 1981, p. 47-53.

Table 1. Total body mass changes in Experiment K-316 rats.

Animal No.	Total Body Mass Preflight 24 Sep 79 (g)	Postflight 14 Oct 79 (g)	Dissection 15 Oct 79 (g)	Change Postflight-Preflight 20 Days (g)	(%)	(g/day)	Change Dissection-Postflight 1 Day (g)	(%)
Flight Animals								
F-26	310	354	343.97	+44	+14.2	+2.20	-10.0	-2.8
F-27	318	372	372.32	+54	+17.0	+2.70	+ 0.3	+0.1
F-28	316	350	344.87	+34	+10.8	+1.70	- 5.1	-1.5
F-29	316	350	339.48	+34	+10.8	+1.70	-10.5	-3.0
F-30	310	360	344.66	+50	+16.1	+2.50	-15.3	-4.3
Mean	314.0	357.2	349.06	+43.2	+13.8	+2.16	- 8.1	-2.3
S.D.	3.7	9.2	13.19	9.1	2.9	0.46	5.9	1.7

	24 Sep 79 (g)	19 Oct 79 (g)	20 Oct 79 (g)	25 Days (g)	(%)	(g/day)	1 Day (g)	(%)
Synchronous Controls								
S-26	306	370	356.62	+64	+20.9	+2.56	-13.4	-3.6
S-27	304	376	366.87	+72	+23.7	+2.88	- 9.1	-2.4
S-28	315	376	361.71	+61	+19.4	+2.44	-14.3	-3.8
S-29	315	366	349.96	+51	+16.2	+2.04	-16.0	-4.4
S-30	314	377	359.14	+63	+20.1	+2.52	-17.9	-4.7
Mean	310.8	373.0	358.86	+62.2	+20.1	+2.49	-14.1	-3.8
S.D.	5.4	4.8	6.26	7.5	2.7	0.30	3.3	0.9

	24 Sep 79 (g)	16 Oct 79 (g)	17 Oct 79 (g)	22 Days (g)	(%)	(g/day)	1 Day (g)	(%)
Vivarium Controls								
V-26	311	382	359.38	+71	+22.8	+3.23	-22.6	-5.9
V-27	303	352	327.93	+49	+16.2	+2.23	-24.1	-6.8
V-28	303	368	348.24	+65	+21.5	+2.95	-19.8	-5.4
V-29	324	380	356.99	+56	+17.3	+2.55	-23.0	-6.1
V-30	310	374	351.65	+64	+20.6	+2.91	-22.3	-6.0
Mean	310.2	371.2	348.84	+61.0	+19.7	+2.77	-22.4	-6.0
S.D.	8.6	12.0	12.48	8.6	2.8	0.39	1.6	0.5

Table 2. Comparison by t-test of preflight and postflight total body mass in the 3 groups of Experiment K-316 rats. Arrows indicate increases (↑) or decreases (↓) significant at the P = .05 level.

			Total Body Mass Mean (g)	C.V.	Difference 2.-1. (g)	(% of 1.)	P
Flight Animals		1. Preflight	314.0	1.2			
	↑	2. Postflight	357.2	2.6	+43.2	+13.8	<.001
Synchronous Controls		1. Preflight	310.8	1.7			
	↑	2. Postflight	373.0	1.3	+62.2	+20.0	<.001
Vivarium Controls		1. Preflight	310.2	2.8			
	↑	2. Postflight	371.2	3.2	+61.0	+19.7	<.001

Table 3. Comparison by t-test of the absolute increase in total body mass (g) between the Flight group and the two Control groups of Experiment K-316 rats during the period of the experiment.

		Accretion of Total Body Mass Mean (g)	C.V.	Difference 2.-1. (g)	(% of 1.)	P
1. Synchronous Controls		62.2	12.1			
2. Flight Animals	↓	43.2	21.1	-19.0	-30.5	0.007
1. Vivarium Controls		61.0	14.1			
2. Flight Animals	↓	43.2	21.1	-17.8	-29.2	0.013
1. Vivarium Controls		61.0	14.1			
2. Synchronous Controls		62.2	12.1	+ 1.2	+ 2.0	0.82

Table 4. Comparison by t-test of rate of increase in total body mass (g/day) between the Flight group and the two Control groups of rats during Experiment K-316.

	Accretion Rate of Total Body Mass Mean (g/day)	C.V.	Difference 2.-1. (g/day)	(% of 1.)	P
1. Synchronous Controls	2.49	12.1			
2. Flight Animals	2.16	21.1	-0.33	-13.2	0.22
1. Vivarium Controls	2.77	14.0			
2. Flight Animals	2.16	21.1	-0.61	-22.1	0.051
1. Vivarium Controls	2.77	14.0			
2. Synchronous	2.49	12.1	-0.28	-10.3	0.23

Table 5. Comparison by t-test of postflight total body mass and total body mass at sacrifice for dissection one day later in the 3 groups of Experiment K-316 rats.

		Total Body Mass Mean (g)	C.V.	Difference 2.-1. (g)	(% of 1.)	P
Flight Animals	1. Postflight	357.2	2.6			
	↓ 2. Dissection	349.06	3.8	- 8.14	-2.3	0.038
Synchronous Controls	1. Postflight	373.0	1.3			
	↓ 2. Dissection	358.86	1.7	-14.14	-3.8	<.001
Vivarium Controls	1. Postflight	371.2	3.2			
	↓ 2. Dissection	348.84	3.6	-22.36	-6.0	<.001

Table 6. Organ system masses in grams of the 5 Flight rats of Experiment K-316 at age 133 ± 1 days on 15 October 1979.

	Animal Number							
Organ System	F-26	F-27	F-28	F-29	F-30	Mean	S.D.	C.V.
Skin	51.28	49.44	53.75	56.33	53.94	52.94	2.65	5.0
Liver	17.90	21.56	16.92	18.44	20.31	19.03	1.88	9.9
Digestive Tract	15.54	16.61	14.92	15.75	17.30	16.02	0.94	5.8
Genitalia	10.56	12.86	12.92	13.25	10.45	12.01	1.38	11.5
Abdominal Fat	14.98	15.97	15.74	14.34	11.21	14.45	1.92	13.3
Kidneys	2.95	2.91	2.68	3.04	3.10	2.94	0.16	5.5
Neck Glands	2.22	2.61	1.88	2.11	1.95	2.15	0.29	13.4
Brain	1.95	1.94	2.03	1.99	2.02	1.99	0.04	2.0
Respiratory Tract	1.88	2.16	1.80	1.95	1.91	1.94	0.13	6.9
Heart	1.12	1.29	1.16	1.44	1.15	1.23	0.13	10.8
Spleen	0.58	0.63	0.53	0.55	0.55	0.57	0.04	6.9
Bladder	0.15	0.16	0.13	0.19	0.14	0.15	0.02	14.9
Adrenals	0.108	0.127	0.111	0.087	0.131	0.113	0.017	15.5
Thyroid	0.021	0.023	0.013	0.025	0.029	0.022	0.006	26.7
Viscera	69.95	78.84	70.83	73.15	70.24	72.60	3.71	5.1
Carcass	184.16	196.10	180.50	170.52	181.90	182.64	9.16	5.0
Blood	22.99	24.42	22.96	22.58	23.04	23.20	0.71	3.0
Net Body Mass	328.38	348.80	328.04	322.58	329.12	331.38	10.08	3.0
Hair	7.33	8.45	6.64	7.96	9.30	7.94	1.02	12.9
Gut Contents	8.26	15.07	10.19	8.94	6.24	9.74	3.30	33.9
Subtotal	15.59	23.52	16.83	16.90	15.54	17.68	3.33	18.8
Total Body Mass	343.97	372.32	344.87	339.48	344.66	349.06	13.19	3.8

Table 7. Organ system masses in grams of the 5 Synchronous Control rats of Experiment K-316 at age 138 ± 1 days on 20 October 1979.

	Animal Number							
Organ System	S-26	S-27	S-28	S-29	S-30	Mean	S.D.	C.V.
Skin	59.29	63.92	59.50	56.41	61.58	60.14	2.80	4.7
Liver	16.89	18.89	17.60	15.64	16.65	17.13	1.21	7.0
Digestive Tract	15.70	15.01	16.36	15.05	16.07	15.64	0.60	3.9
Genitalia	12.49	12.62	13.77	13.09	12.26	12.85	0.60	4.7
Abdominal Fat	13.22	9.31	17.83	15.64	14.81	14.16	3.18	22.5
Kidneys	2.63	2.75	2.86	2.53	2.84	2.72	0.14	5.2
Neck Glands	2.06	1.87	1.98	2.06	1.92	1.98	0.08	4.3
Brain	2.04	1.80	2.06	1.86	2.00	1.95	0.12	5.9
Respiratory Tract	1.70	2.06	1.98	1.78	1.85	1.87	0.15	7.8
Heart	1.35	1.37	1.22	1.19	1.07	1.24	0.12	9.9
Spleen	0.63	0.68	0.66	0.59	0.72	0.66	0.05	7.5
Bladder	0.12	0.20	0.16	0.20	0.15	0.17	0.03	20.7
Adrenals	0.101	0.126	0.134	0.127	0.122	0.122	0.013	10.3
Thyroid	0.015	0.017	0.023	0.019	0.026	0.020	0.004	22.4
Viscera	68.94	66.70	76.63	69.77	70.49	70.50	3.71	5.3
Carcass	191.61	190.99	188.79	189.47	188.69	189.91	1.32	0.7
Blood	24.07	24.21	24.46	23.76	24.14	24.13	0.25	1.0
Net Body Mass	343.91	345.82	349.38	339.41	344.90	344.68	3.60	1.0
Hair	6.66	6.57	7.44	6.65	7.23	6.91	0.40	5.7
Gut Contents	6.05	14.48	4.89	3.90	7.01	7.27	4.20	57.8
Subtotal	12.71	21.05	12.33	10.55	14.24	14.18	4.06	28.6
Total Body Mass	356.62	366.87	361.71	349.96	359.14	358.86	6.26	1.7

Table 8. Organ system masses in grams of the 5 Vivarium Control rats of Experiment K-316 at age 135 ± 1 days on 17 October 1979.

Organ System	V-26	V-27	V-28	V-29	V-30	Mean	S.D.	C.V.
	Animal Number							
Skin	59.68	53.91	59.59	59.92	57.96	58.21	2.53	4.3
Liver	15.99	16.11	15.66	16.41	15.50	15.93	0.36	2.3
Digestive Tract	12.60	12.02	15.23	13.35	14.20	13.48	1.28	9.5
Genitalia	11.58	12.15	11.55	11.22	12.41	11.78	0.48	4.1
Abdominal Fat	6.86	4.05	10.77	7.98	9.86	7.90	2.65	33.5
Kidneys	2.55	2.04	2.49	2.66	2.55	2.46	0.24	9.8
Neck Glands	1.52	1.77	1.72	1.85	1.63	1.70	0.13	7.5
Brain	1.89	2.01	2.00	2.14	2.12	2.03	0.10	5.0
Respiratory Tract	1.69	1.97	1.85	2.53	1.86	1.98	0.32	16.3
Heart	1.10	1.17	1.28	1.56	1.12	1.25	0.19	15.2
Spleen	0.75	0.91	0.67	0.62	0.58	0.71	0.13	18.5
Bladder	0.15	0.17	0.15	0.11	0.19	0.15	0.03	19.3
Adrenals	0.134	0.113	0.103	0.122	0.070	0.108	0.024	22.4
Thyroid	0.022	0.027	0.025	0.021	0.030	0.025	0.004	14.7
Viscera	56.83	54.51	63.49	60.57	62.12	59.50	3.74	6.3
Carcass	204.13	184.23	190.51	201.01	195.00	194.98	7.99	4.1
Blood	24.13	22.03	23.60	24.20	23.72	23.54	0.88	3.7
Net Body Mass	344.77	314.68	337.19	345.70	338.80	336.23	12.60	3.7
Hair	7.76	6.64	6.78	6.08	7.02	6.86	0.61	8.9
Gut Contents	6.85	6.61	4.27	5.21	5.83	5.75	1.05	18.3
Subtotal	14.61	13.25	11.05	11.29	12.85	12.61	1.47	11.7
Total Body Mass	359.38	327.93	348.24	356.99	351.65	348.84	12.48	3.6

Table 9. Organ system mean gram mass differences between the 5 Flight rats and the 5 Synchronous Control rats of Experiment K-316. P is the probability that two means are statistically the same, and the vertical arrows indicate the mean values that are significantly different at the P = .05 level. The direction of the arrows indicates whether the Flight means are lower (↓) or higher (↑) than the Synchronous Control means.

Organ System		Flight Mean (g)	Flight C.V.	Synchronous Mean (g)	Synchronous C.V.	Difference Col. 2 - Col. 4 (g)	Difference Col. 2 - Col. 4 (%)	P
Skin	↓	52.94	5.0	60.14	4.7	- 7.20	-12.0	0.003
Liver		19.03	9.9	17.13	7.0	+ 1.90	+11.0	0.095
Digestive Tract		16.02	5.8	15.64	3.9	+ 0.38	+ 2.5	0.46
Genitalia		12.01	11.5	12.85	4.7	- 0.84	- 6.5	0.25
Abdominal Fat		14.45	13.3	14.16	22.5	+ 0.29	+ 2.0	0.87
Kidneys		2.94	5.5	2.72	5.2	+ 0.22	+ 7.9	0.056
Neck Glands		2.15	13.4	1.98	4.3	+ 0.17	+ 8.9	0.23
Brain		1.99	2.0	1.95	5.9	+ 0.04	+ 1.7	0.55
Respiratory Tract		1.94	6.9	1.87	7.8	+ 0.07	+ 3.5	0.48
Heart		1.23	10.8	1.24	9.9	- 0.01	- 0.6	0.92
Spleen	↓	0.57	6.9	0.66	7.5	- 0.09	-13.4	0.014
Bladder		0.15	14.9	0.17	20.7	- 0.02	- 7.2	0.53
Adrenals		0.113	15.5	0.122	10.3	- 0.009	- 7.5	0.37
Thyroid		0.022	26.7	0.020	22.4	+ 0.002	+11.0	0.53
Viscera		72.60	5.1	70.50	5.3	+ 2.10	+ 3.0	0.40
Carcass		182.64	5.0	189.91	0.7	- 7.27	- 3.8	0.12
Blood	↓	23.20	3.0	24.13	1.0	- 0.93	- 3.9	0.024
Net Body Mass	↓	331.38	3.0	344.68	1.0	-13.30	- 3.9	0.024
Hair		7.94	12.9	6.91	5.7	+ 1.03	+14.8	0.070
Gut Contents		9.74	33.9	7.27	57.8	+ 2.47	+34.0	0.33
Subtotal		17.68	18.8	14.18	28.6	+ 3.50	+24.7	0.17
Total Body Mass		349.06	3.8	358.86	1.7	- 9.80	- 2.7	0.17

Table 10. Organ system mean gram mass differences between the 5 Flight rats and the 5 Vivarium Control rats of Experiment K-316.

Organ System		Flight Mean (g)	Flight C.V.	Vivarium Mean (g)	Vivarium C.V.	Difference Col. 2 - Col. 4 (g)	Difference Col. 2 - Col. 4 (%)	P
Skin	↓	52.94	5.0	58.21	4.3	- 5.27	- 9.0	0.012
Liver	↑	19.03	9.9	15.93	2.3	+ 3.10	+19.4	0.007
Digestive Tract	↑	16.02	5.8	13.48	9.5	+ 2.54	+18.9	0.007
Genitalia		12.01	11.5	11.78	4.1	+ 0.23	+ 1.9	0.74
Abdominal Fat	↑	14.45	13.3	7.90	33.5	+ 6.55	+82.8	0.002
Kidneys		2.94	5.5	2.46	9.8	+ 0.48	+19.4	0.006
Neck Glands	↑	2.15	13.4	1.70	7.5	+ 0.45	+26.9	0.012
Brain		1.99	2.0	2.03	5.0	- 0.04	- 2.3	0.37
Respiratory Tract		1.94	6.9	1.98	16.3	- 0.04	- 2.0	0.80
Heart		1.23	10.8	1.25	15.2	- 0.02	- 1.1	0.90
Spleen		0.57	6.9	0.71	18.5	- 0.14	-19.5	0.053
Bladder		0.15	14.9	0.15	19.3	0.00	0.0	1.00
Adrenals		0.113	15.5	0.108	22.4	+ 0.005	+ 4.1	0.75
Thyroid		0.022	26.7	0.025	14.7	- 0.003	-11.2	0.40
Viscera	↑	72.60	5.1	59.50	6.3	+13.10	+22.0	<.001
Carcass		182.64	5.0	194.98	4.1	-12.34	- 6.3	0.053
Blood		23.20	3.0	23.54	3.7	- 0.34	- 1.4	0.52
Net Body Mass		331.38	3.0	336.23	3.7	- 4.85	- 1.4	0.52
Hair		7.94	12.9	6.86	8.9	+ 1.08	+15.8	0.077
Gut Contents	↑	9.74	33.9	5.75	18.3	+ 3.99	+69.3	0.033
Subtotal	↑	17.68	18.8	12.61	11.7	+ 5.07	+40.2	0.014
Total Body Mass		349.06	3.8	348.84	3.6	+ 0.22	+ 0.6	0.79

Table 11. Organ system mean gram mass differences between the 5 Synchronous Control rats and the 5 Vivarium Control rats of Experiment K-316.

Organ System		Synchronous Mean (g)	C.V.	Vivarium Mean (g)	C.V.	Difference Col. 2 - Col. 4 (g)	(%)	P
Skin		60.14	4.7	58.21	4.3	+ 1.93	+ 3.3	0.29
Liver		17.13	7.0	15.93	2.3	+ 1.20	+ 7.5	0.066
Digestive Tract	†	15.64	3.9	13.48	9.5	+ 2.16	+16.0	0.009
Genitalia	†	12.85	4.7	11.78	4.1	+ 1.07	+ 9.0	0.015
Abdominal Fat	†	14.16	22.5	7.90	33.5	+ 6.26	+79.2	0.010
Kidneys		2.72	5.2	2.46	9.8	+ 0.26	+10.7	0.068
Neck Glands	†	1.98	4.3	1.70	7.5	+ 0.28	+16.5	0.003
Brain		1.95	5.9	2.03	5.0	- 0.08	- 3.9	0.28
Respiratory Tract		1.87	7.8	1.98	16.3	- 0.11	- 5.4	0.52
Heart		1.24	9.9	1.25	15.2	- 0.01	- 0.5	0.95
Spleen		0.66	7.5	0.71	18.5	- 0.05	- 7.1	0.45
Bladder		0.17	20.7	0.15	19.3	+ 0.02	+ 7.8	0.57
Adrenals		0.122	10.3	0.108	22.4	+ 0.014	+12.5	0.30
Thyroid		0.020	22.4	0.025	14.7	- 0.005	-20.0	0.089
Viscera	†	70.50	5.3	59.50	6.3	+11.00	+18.5	0.002
Carcass		189.91	0.7	194.98	4.1	- 5.07	- 2.6	0.20
Blood		24.13	1.0	23.54	3.7	+ 0.59	+ 2.5	0.19
Net Body Mass		344.68	1.0	336.23	3.7	+ 8.45	+ 2.5	0.19
Hair		6.91	5.7	6.86	8.9	+ 0.05	+ 0.8	0.87
Gut Contents		7.27	57.8	5.75	18.3	+ 1.52	+26.3	0.46
Subtotal		14.18	28.6	12.61	11.7	+ 1.57	+12.4	0.44
Total Body Mass		358.86	1.7	348.84	3.6	+10.02	+ 2.9	0.15

Table 12. Water, fat, and fat-free masses, in grams, of the major body components of the 5 Flight rats of Experiment K-316.

Component	F-26	F-27	F-28	F-29	F-30	Mean	S.D.	C.V.
Carcass								
Wet Mass	184.16	196.10	180.50	170.52	181.90	182.64	9.16	5.0
Dry Mass	72.24	74.68	70.26	66.93	70.35	70.89	2.85	4.0
Water Mass	111.92	121.42	110.24	103.59	111.55	111.75	6.37	5.7
Fat Mass	22.03	18.91	19.82	18.53	19.05	19.67	1.40	7.1
Fat-Free Mass	162.13	177.19	160.68	151.99	162.85	162.97	9.07	5.6
Dry Fat-Free Mass	50.21	55.77	50.44	48.40	51.30	51.22	2.75	5.4
Viscera								
Wet Mass	69.95	78.84	70.83	73.15	70.24	72.60	3.71	5.1
Dry Mass	36.92	40.32	39.29	37.89	33.89	37.66	2.48	6.6
Water Mass	33.03	38.52	31.54	35.26	36.35	34.94	2.74	7.9
Fat Mass	25.19	27.56	27.78	26.26	21.76	25.71	2.44	9.5
Fat-Free Mass	44.76	51.28	43.05	46.89	48.48	46.89	3.20	6.8
Dry Fat-Free Mass	11.73	12.76	11.51	11.63	12.13	11.95	0.51	4.3
Skin								
Wet Mass	51.28	49.44	53.75	56.33	53.94	52.94	2.65	5.0
Dry Mass	25.11	24.27	27.39	32.38	27.33	27.30	3.15	11.6
Water Mass	26.17	25.17	26.36	23.95	26.61	25.64	1.10	4.3
Fat Mass	12.61	11.64	14.06	20.11	13.37	14.36	3.34	23.3
Fat-Free Mass	38.67	37.80	39.69	36.22	40.57	38.59	1.69	4.4
Dry Fat-Free Mass	12.50	12.63	13.33	12.27	13.96	12.94	0.69	5.4
Blood	22.99	24.42	22.96	22.58	23.04	23.20	0.71	3.0
Net Body								
Wet Mass	328.38	348.80	328.04	322.58	329.12	331.38	10.08	3.0
Dry Mass	134.27	139.27	136.94	137.20	131.57	135.85	2.98	2.2
Water Mass	194.11	209.53	191.10	185.38	197.55	195.53	9.01	4.6
Fat Mass	59.83	58.11	61.66	64.90	54.18	59.74	4.00	6.7
Fat-Free Mass	268.55	290.69	266.38	257.68	274.94	271.65	12.31	4.5
Dry Fat-Free Mass	74.44	81.16	75.28	72.30	77.39	76.11	3.36	4.4

Table 13. Water, fat, and fat-free masses, in grams, of the major body components of the 5 Synchronous Control rats of Experiment K-316.

Component	S-26	S-27	S-28	S-29	S-30	Mean	S.D.	C.V.
Carcass								
Wet Mass	191.61	190.99	188.79	189.47	188.69	189.91	1.32	0.7
Dry Mass	70.42	67.56	71.99	72.20	69.40	70.31	1.92	2.7
Water Mass	121.19	123.43	116.80	117.27	119.29	119.60	2.76	2.3
Fat Mass	18.32	12.21	21.44	20.29	16.26	17.70	3.65	20.6
Fat-Free Mass	173.29	178.78	167.35	169.18	172.43	172.21	4.39	2.6
Dry Fat-Free Mass	52.10	55.35	50.55	51.91	53.14	52.61	1.79	3.4
Viscera								
Wet Mass	68.94	66.70	76.63	69.77	70.49	70.50	3.71	5.3
Dry Mass	34.94	31.17	40.39	36.49	35.33	35.66	3.31	9.3
Water Mass	34.00	35.53	36.24	33.28	35.16	34.84	1.19	3.4
Fat Mass	23.05	19.23	28.00	24.67	23.53	23.70	3.16	13.3
Fat-Free Mass	45.89	47.47	48.63	45.10	46.96	46.80	1.37	2.9
Dry Fat-Free Mass	11.89	11.94	12.39	11.82	11.80	11.96	0.24	2.0
Skin								
Wet Mass	59.29	63.92	59.50	56.41	61.58	60.14	2.80	4.7
Dry Mass	29.46	28.89	28.64	28.26	30.54	29.16	0.89	3.0
Water Mass	29.83	35.03	30.86	28.15	31.04	30.98	2.54	8.2
Fat Mass	15.49	12.66	14.84	15.12	16.56	14.93	1.43	9.6
Fat-Free Mass	43.80	51.26	44.66	41.29	45.02	45.21	3.68	8.1
Dry Fat-Free Mass	13.97	16.23	13.80	13.14	13.98	14.23	1.17	8.2
Blood	24.07	24.21	24.46	23.76	24.14	24.13	0.25	1.0
Net Body								
Wet Mass	343.91	345.82	349.38	339.41	344.90	344.68	3.60	1.0
Dry Mass	134.82	127.62	141.02	136.95	135.27	135.13	4.86	3.6
Water Mass	209.09	218.20	208.36	202.46	209.63	209.55	5.63	2.7
Fat Mass	56.86	44.10	64.28	60.08	56.35	56.33	7.54	13.4
Fat-Free Mass	287.05	301.72	285.10	279.33	288.55	288.35	8.25	2.9
Dry Fat-Free Mass	77.96	83.52	76.74	76.87	78.92	78.80	2.78	3.5

Table 14. Water, fat, and fat-free masses, in grams, of the major body components of the 5 Vivarium Control rats of Experiment K-316.

Component	V-26	V-27	V-28	V-29	V-30	Mean	S.D.	C.V.
			Animal Number					
Carcass								
Wet Mass	204.13	184.23	190.51	201.01	195.00	194.98	7.99	4.1
Dry Mass	68.33	59.61	65.80	67.32	66.90	65.59	3.46	5.3
Water Mass	135.80	124.62	124.71	133.69	128.10	129.39	5.15	4.0
Fat Mass	7.99	5.03	12.15	9.50	12.11	9.35	3.00	32.1
Fat-Free Mass	196.14	179.20	178.36	191.51	182.89	185.63	7.85	4.2
Dry Fat-Free Mass	60.34	54.58	53.65	57.82	54.79	56.24	2.78	4.9
Viscera								
Wet Mass	56.83	54.41	63.49	60.57	62.12	59.50	3.74	6.3
Dry Mass	21.65	18.28	28.97	24.78	26.80	24.10	4.22	17.5
Water Mass	35.18	36.23	34.52	35.79	35.32	35.40	0.65	1.8
Fat Mass	10.61	6.79	17.54	13.14	15.96	12.81	4.29	33.5
Fat-Free Mass	46.22	47.72	45.95	47.43	46.16	46.69	0.82	1.7
Dry Fat-Free Mass	11.04	11.49	11.43	11.64	10.84	11.29	0.33	3.0
Skin								
Wet Mass	59.68	53.91	59.59	59.92	57.96	58.21	2.53	4.3
Dry Mass	23.25	20.17	26.53	25.80	26.48	24.44	2.74	11.2
Water Mass	36.43	33.74	33.06	34.12	31.48	33.77	1.80	5.3
Fat Mass	6.74	4.94	11.57	10.79	12.35	9.28	3.25	35.0
Fat-Free Mass	52.94	48.97	48.02	49.13	45.61	48.93	2.64	5.4
Dry Fat-Free Mass	16.51	15.23	14.96	15.01	14.13	15.16	0.86	5.7
Blood	24.13	22.03	23.60	24.20	23.72	23.54	0.88	3.7
Net Body								
Wet Mass	344.77	314.68	337.19	345.70	338.80	336.23	12.60	3.7
Dry Mass	113.23	98.06	121.30	117.90	120.18	114.13	9.50	8.3
Water Mass	231.54	216.62	215.89	227.80	218.62	222.10	7.11	3.2
Fat Mass	25.34	16.76	41.26	33.43	40.42	31.44	10.41	33.1
Fat-Free Mass	319.43	297.92	295.93	312.27	298.38	304.79	10.45	3.4
Dry Fat-Free Mass	87.89	81.30	80.04	84.47	79.76	82.69	3.45	4.2

Table 15. Fat, fat-free, dry fat-free, and water mean gram mass differences of the major body components between the 5 Flight rats and the 5 Synchronous Control rats of Experiment K-316.

Component		Flight Mean (g)	Flight C.V.	Synchronous Mean (g)	Synchronous C.V.	Difference Col. 2 - Col. 4 (g)	Difference (%)	P
Total Body		349.06	3.8	358.86	1.7	- 9.80	- 2.7	0.17
Net Body	↓	331.38	3.0	344.68	1.0	-13.30	- 3.9	0.024
Fat:								
Carcass		19.67	7.1	17.70	20.6	+ 1.97	+11.1	0.29
Viscera		25.71	9.5	23.70	13.3	+ 2.01	+ 8.5	0.29
Skin		14.36	23.3	14.93	9.6	- 0.57	- 3.9	0.73
Body		59.74	6.7	56.33	13.4	+ 3.41	+ 6.0	0.40
Fat-Free:								
Carcass		162.97	5.6	172.21	2.6	- 9.24	- 5.4	0.074
Viscera		46.89	6.8	46.80	2.9	+ 0.09	+ 0.2	0.96
Skin	↓	38.59	4.4	45.21	8.1	- 6.62	-14.6	0.006
Blood	↓	23.20	3.0	24.13	1.0	- 0.93	- 3.9	0.024
Body	↓	271.65	4.5	288.35	2.9	-16.70	- 5.8	0.036
Dry Fat-Free:								
Carcass		51.22	5.4	52.61	3.4	- 1.39	- 2.6	0.37
Viscera		11.95	4.3	11.96	2.0	- 0.01	- 0.1	0.95
Skin		12.94	5.4	14.23	8.2	- 1.29	- 9.0	0.068
Body		76.11	4.4	78.80	3.5	- 2.69	- 3.4	0.21
Water:								
Carcass	↓	111.75	5.7	119.60	2.3	- 7.85	- 6.6	0.035
Viscera		34.94	7.9	34.84	3.4	+ 0.10	+ 0.3	0.94
Skin	↓	25.64	4.3	30.98	8.2	- 5.34	- 17.2	0.003
Blood	↓	23.20	3.0	24.13	1.0	- 0.93	- 3.9	0.024
Body	↓	195.53	4.6	209.55	2.7	-14.02	- 6.7	0.018
Intracellular		150.66	5.4	139.15	6.6	+11.51	+ 8.3	0.069
Extracellular	↓	44.87	17.5	70.40	6.9	-25.53	-36.3	<.001

Table 16. Fat, fat-free, dry fat-free, and water mean gram mass differences of the major body components between the 5 Flight rats and the 5 Vivarium Control rats of Experiment K-316.

Component		Flight Mean (g)	Flight C.V.	Vivarium Mean (g)	Vivarium C.V.	Difference Col. 2 - Col. 4 (g)	Difference Col. 2 - Col. 4 (%)	P
Total Body		349.06	3.8	348.84	3.6	+ 0.22	+ 0.6	0.79
Net Body		331.38	3.0	336.23	3.7	- 4.85	- 1.4	0.52
Fat:								
Carcass	↑	19.67	7.1	9.35	32.1	+10.32	+110.2	<.001
Viscera	↑	25.71	9.5	12.81	33.5	+12.90	+100.7	<.001
Skin	↑	14.36	23.3	9.28	35.0	+ 5.08	+ 54.8	0.041
Body	↑	59.74	6.7	31.44	33.1	+28.30	+ 90.0	<.001
Fat-Free:								
Carcass	↓	162.97	5.6	185.63	4.2	-22.66	-12.2	0.003
Viscera		46.89	6.8	46.69	1.7	+ 0.20	+ 0.4	0.90
Skin	↓	38.59	4.4	48.93	5.4	-10.34	-21.1	<.001
Blood		23.20	3.0	23.54	3.7	- 0.34	- 1.4	0.52
Body	↓	271.65	4.5	304.79	3.4	-33.14	-10.9	0.002
Dry Fat-Free:								
Carcass	↓	51.22	5.4	56.24	4.9	- 5.02	- 8.9	0.021
Viscera	↑	11.95	4.3	11.29	3.0	+ 0.66	+ 5.9	0.041
Skin	↓	12.94	5.4	15.16	5.7	- 2.22	-14.7	0.002
Body	↓	76.11	4.4	82.69	4.2	- 6.58	- 8.0	0.016
Water:								
Carcass	↓	111.75	5.7	129.39	4.0	-17.64	-13.6	0.001
Viscera		34.94	7.9	35.40	1.8	- 0.46	- 1.3	0.72
Skin	↓	25.64	4.3	33.77	5.3	- 8.13	-24.0	<.001
Blood		23.20	3.0	23.54	3.7	- 0.34	- 1.4	0.52
Body	↓	195.53	4.6	222.10	3.2	-26.57	-12.0	<.001
Intracellular		150.66	5.4	152.60	7.6	- 1.94	- 1.3	0.77
Extracellular	↓	44.87	17.5	69.50	11.7	-24.63	-35.4	0.001

Table 17. Fat, fat-free, dry fat-free, and water mean gram mass differences of the major body components between the 5 Synchronous Control rats and the 5 Vivarium Control rats of Experiment K-316.

Component		Synchronous Mean (g)	C.V.	Vivarium Mean (g)	C.V.	Difference Col. 2 - Col. 4 (g)	(%)	P
Total Body		358.86	1.7	348.84	3.6	+10.02	+ 2.9	0.15
Net Body		344.68	1.0	336.23	3.7	+ 8.45	+ 2.5	0.19
Fat:								
Carcass	↑	17.70	20.6	9.35	32.1	+ 8.35	+89.2	0.004
Viscera	↑	23.70	13.3	12.81	33.5	+10.89	+85.0	0.002
Skin	↑	14.93	9.6	9.28	35.0	+ 5.65	+61.0	0.007
Body	↑	56.33	13.4	31.44	33.1	+24.89	+79.2	0.003
Fat-Free:								
Carcass	↓	172.21	2.6	185.63	4.2	-13.42	- 7.2	0.010
Viscera		46.80	2.9	46.69	1.7	+ 0.11	+ 0.2	0.88
Skin		45.21	8.1	48.93	5.4	- 3.72	- 7.6	0.10
Blood		24.13	1.0	23.54	3.7	+ 0.59	+ 2.5	0.19
Body	↓	288.35	2.9	304.79	3.4	-16.44	- 5.4	0.025
Dry Fat-Free:								
Carcass	↓	52.61	3.4	56.24	4.9	- 3.63	- 6.4	0.040
Viscera	↑	11.96	2.0	11.29	3.0	+ 0.67	+ 6.0	0.006
Skin		14.23	8.2	15.16	5.7	- 0.93	- 6.2	0.18
Body		78.80	3.5	82.69	4.2	- 3.89	- 4.7	0.086
Water:								
Carcass	↓	119.60	2.3	129.39	4.0	- 9.79	- 7.6	0.006
Viscera		34.84	3.4	35.40	1.8	- 0.56	- 1.6	0.38
Skin		30.98	8.2	33.77	5.3	- 2.79	- 8.2	0.080
Blood		24.13	1.0	23.54	3.7	+ 0.59	+ 2.5	0.19
Body	↓	209.55	2.7	222.10	3.2	-12.55	- 5.6	0.015
Intracellular		139.15	6.6	152.60	7.6	-13.45	- 8.8	0.077
Extracellular		70.40	6.9	69.50	11.7	+ 0.90	+ 1.3	0.84

Table 18. Fat and water fractions, as per cent, of the major body components of the 5 Flight rats of Experiment K-316.

Fraction	F-26	F-27	F-28	F-29	F-30	Mean	S.D.	C.V.
[Component Fat/Total Component] x 100								
Carcass	12.0	9.6	11.0	10.9	10.5	10.8	0.9	8.0
Viscera	36.0	35.0	39.2	35.9	31.0	35.4	2.9	8.3
Skin	24.6	23.5	26.2	35.7	24.8	27.0	5.0	18.5
Net Body	18.2	16.7	18.8	20.1	16.5	18.1	1.5	8.3
[Component Fat/Total Fat] x 100								
Carcass	36.8	32.6	32.1	28.5	35.2	33.0	3.2	9.6
Viscera	42.1	47.4	45.1	40.5	40.2	43.1	3.1	7.2
Skin	21.1	20.0	22.8	31.0	24.6	23.9	4.3	18.1
Net Body	100.0	100.0	100.0	100.0	100.0	100.0		
[Component Water/Fat-Free Component] x 100								
Carcass	69.0	68.5	68.6	68.2	68.5	68.6	0.3	0.4
Viscera	73.8	75.1	73.3	75.2	75.0	74.5	0.9	1.2
Skin	67.7	66.6	66.4	66.1	65.6	66.5	0.8	1.2
Net Body	72.3	72.1	71.7	71.9	71.9	72.0	0.2	0.3
[Component Water/Total Water] x 100								
Carcass	57.7	57.9	57.7	55.9	56.5	57.1	0.9	1.6
Viscera	17.0	18.4	16.5	19.0	18.4	17.9	1.1	5.9
Skin	13.5	12.0	13.8	12.9	13.5	13.1	0.7	5.5
Blood	11.8	11.7	12.0	12.2	11.6	11.9	0.2	2.0
Net Body	100.0	100.0	100.0	100.0	100.0	100.0		

Table 19. Fat and water fractions, as per cent, of the major body components of the 5 Synchronous Control rats of Experiment K-316.

Fraction	Animal Number S-26	S-27	S-28	S-29	S-30	Mean	S.D.	C.V.
[Component Fat/Total Component] x 100								
Carcass	9.6	6.4	11.4	10.7	8.6	9.3	2.0	21.0
Viscera	33.4	28.8	36.5	35.4	33.4	33.5	2.9	8.8
Skin	26.1	19.8	24.9	26.8	26.9	24.9	3.0	11.9
Net Body	16.5	12.8	18.4	17.7	16.3	16.3	2.2	13.2
[Component Fat/Total Fat] x 100								
Carcass	32.2	27.7	33.3	33.8	28.9	31.2	2.7	8.7
Viscera	40.5	43.6	43.6	41.0	41.7	42.1	1.5	3.4
Skin	27.3	28.7	23.1	25.2	29.4	26.7	2.6	9.7
Net Body	100.0	100.0	100.0	100.0	100.0	100.0		
[Component Water/Fat-Free Component] x 100								
Carcass	69.9	69.0	69.8	69.3	69.2	69.4	0.4	0.6
Viscera	74.1	74.8	74.5	73.8	74.9	74.4	0.5	0.6
Skin	68.1	68.3	69.1	68.2	68.9	68.5	0.4	0.7
Net Body	72.8	72.3	73.1	72.5	72.6	72.7	0.3	0.4
[Component Water/Total Water] x 100								
Carcass	57.9	56.6	56.1	57.9	56.9	57.1	0.8	1.4
Viscera	16.3	16.3	17.4	16.5	16.8	16.6	0.5	2.8
Skin	14.3	16.0	14.8	13.9	14.8	14.8	0.8	5.3
Blood	11.5	11.1	11.7	11.7	11.5	11.5	0.2	2.1
Net Body	100.0	100.0	100.0	100.0	100.0	100.0		

Table 20. Fat and water fractions, as per cent, of the major body components of the 5 Vivarium Control rats of Experiment K-316.

Fraction	Animal Number V-26	V-27	V-28	V-29	V-30	Mean	S.D.	C.V.
[Component Fat/Total Component] x 100								
Carcass	3.9	2.7	6.4	4.7	6.2	4.8	1.6	32.7
Viscera	18.7	12.5	27.6	21.7	25.7	21.2	6.0	28.2
Skin	11.3	9.2	19.4	18.0	21.3	15.8	5.3	33.4
Net Body	7.3	5.3	12.2	9.7	11.9	9.3	3.0	32.0
[Component Fat/Total Fat] x 100								
Carcass	31.5	30.0	29.5	28.4	30.0	29.9	1.1	3.7
Viscera	41.9	40.5	42.5	39.3	39.5	40.7	1.4	3.5
Skin	26.6	29.5	28.0	32.3	30.5	29.4	2.2	7.5
Net Body	100.0	100.0	100.0	100.0	100.0	100.0		
[Component Water/Fat-Free Component] x 100								
Carcass	69.2	69.5	69.9	69.8	70.0	69.7	0.3	0.5
Viscera	76.1	75.9	75.1	75.5	76.5	75.8	0.5	0.7
Skin	68.8	68.9	68.8	69.4	69.0	69.0	0.2	0.4
Net Body	72.5	72.7	73.0	72.9	73.3	72.9	0.3	0.4
[Component Water/Total Water] x 100								
Carcass	58.7	57.5	57.8	58.7	58.6	58.2	0.6	1.0
Viscera	15.2	16.7	16.0	15.7	16.2	16.0	0.6	3.5
Skin	15.7	15.6	15.3	15.0	14.4	15.2	0.5	3.5
Blood	10.4	10.2	10.9	10.6	10.8	10.6	0.3	2.7
Net Body	100.0	100.0	100.0	100.0	100.0	100.0		

Table 21. Mean differences in major body component fat and water percentages between the 5 Flight rats and the 5 Synchronous Control rats of Experiment K-316.

	Flight		Synchronous		Difference Col. 2 - Col. 4		
Fraction	Mean	C.V.	Mean	C.V.	Mean	%	P
[Component Fat/Total Component] x 100							
Carcass	10.8	8.0	9.3	21.0	+ 1.5	+15.6	0.17
Viscera	35.4	8.3	33.5	8.8	+ 1.9	+ 5.7	0.33
Skin	27.0	18.5	24.9	11.9	+ 2.1	+ 8.3	0.45
Net Body	18.1	8.3	16.3	13.2	+ 1.8	+10.5	0.18
[Component Fat/Total Fat] x 100							
Carcass	33.0	9.6	31.2	8.7	+ 1.8	+ 6.0	0.35
Viscera	43.1	7.2	42.1	3.4	+ 1.0	+ 2.3	0.54
Skin	23.9	18.1	26.7	9.7	- 2.8	-10.6	0.24
[Component Water/Fat-Free Component] x 100							
Carcass	↓ 68.6	0.4	69.4	0.6	- 0.8	- 1.3	0.004
Viscera	74.5	1.2	74.4	0.6	+ 0.1	+ 0.1	0.90
Skin	↓ 66.5	1.2	68.5	0.7	- 2.0	- 3.0	<.001
Net Body	↓ 72.0	0.3	72.7	0.4	- 0.7	- 0.9	0.004
[Component Water/Total Water] x 100							
Carcass	57.1	1.6	57.1	1.4	0.0	+ 0.1	0.91
Viscera	↑ 17.9	5.9	16.6	2.8	+ 1.3	+ 7.2	0.048
Skin	↓ 13.1	5.5	14.8	5.3	- 1.7	-11.0	0.009
Blood	↑ 11.9	2.0	11.5	2.1	+ 0.4	+ 3.1	0.047

Table 22. Mean differences in major body component fat and water percentages between the 5 Flight rats and the 5 Vivarium Control rats of Experiment K-316.

Fraction		Flight Mean	Flight C.V.	Vivarium Mean	Vivarium C.V.	Difference Col. 2 - Col. 4 Mean	Difference Col. 2 - Col. 4 %	P
[Component Fat/Total Component] x 100								
Carcass	↑	10.8	8.0	4.8	32.7	+ 6.0	+125.9	<.001
Viscera	↑	35.4	8.3	21.2	28.2	+14.2	+ 66.8	0.001
Skin	↑	27.0	18.5	15.8	33.4	+11.2	+ 70.2	0.009
Net Body	↑	18.1	8.3	9.3	32.0	+ 8.8	+ 94.6	<.001
[Component Fat/Total Fat] x 100								
Carcass		33.0	9.6	29.9	3.7	+ 3.1	+10.6	0.069
Viscera		43.1	7.2	40.7	3.5	+ 2.4	+ 5.7	0.17
Skin	↓	23.9	18.1	29.4	7.5	- 5.5	-18.7	0.036
[Component Water/Fat-Free Component] x 100								
Carcass	↓	68.6	0.4	69.7	0.5	- 1.1	- 1.6	<.001
Viscera	↓	74.5	1.2	75.8	0.7	- 1.3	- 1.8	0.019
Skin	↓	66.5	1.2	69.0	0.4	- 2.5	- 3.6	<.001
Net Body	↓	72.0	0.3	72.9	0.4	- 0.9	- 1.2	<.001
[Component Water/Total Water] x 100								
Carcass	↓	57.1	1.6	58.2	1.0	- 1.1	- 1.9	0.045
Viscera	↑	17.9	5.9	16.0	3.5	+ 1.9	+11.9	0.007
Skin	↓	13.1	5.5	15.2	3.5	- 2.1	-13.6	<.001
Blood	↑	11.9	2.0	10.6	2.7	+ 1.3	+12.1	<.001

Table 23. Mean differences in major body component fat and water percentages between the 5 Synchronous Control rats and the 5 Vivarium Control rats of Experiment K-316.

Fraction		Synchronous Mean	Synchronous C.V.	Vivarium Mean	Vivarium C.V.	Difference Col. 2 - Col. 4 Mean	Difference Col. 2 - Col. 4 %	P
[Component Fat/Total Component] x 100								
Carcass	↑	9.3	21.0	4.8	32.7	+ 4.5	+95.4	0.004
Viscera	↑	33.5	8.8	21.2	28.2	+12.3	+57.7	0.003
Skin	↑	24.9	11.9	15.8	33.4	+ 9.1	+57.2	0.010
Net Body	↑	16.3	13.2	9.3	32.0	+ 7.0	+76.1	0.003
[Component Fat/Total Fat] x 100								
Carcass		31.2	8.7	29.9	3.7	+ 1.3	+ 4.4	0.35
Viscera		42.1	3.4	40.7	3.5	+ 1.4	+ 3.3	0.18
Skin		26.7	9.7	29.4	7.5	- 2.7	- 9.0	0.12
[Component Water/Fat-Free Component] x 100								
Carcass		69.4	0.6	69.7	0.5	- 0.3	- 0.3	0.32
Viscera	↓	74.4	0.6	75.8	0.7	- 1.4	- 1.8	0.002
Skin		68.5	0.7	69.0	0.4	- 0.5	- 0.7	0.080
Net Body		72.7	0.4	72.9	0.4	- 0.2	- 0.3	0.29
[Component Water/Total Water] x 100								
Carcass	↓	57.1	1.4	58.2	1.0	- 1.1	- 2.0	0.028
Viscera		16.6	2.8	16.0	3.5	+ 0.6	+ 4.2	0.063
Skin		14.8	5.3	15.2	3.5	- 0.4	- 2.9	0.33
Blood	↑	11.5	2.1	10.6	2.7	+ 0.9	+ 8.7	<.001

Table 24. Body composition parameters measured or derived by analysis of the dry, fat-free body powder from the 5 Flight rats of Experiment K-316.

Parameter	F-26	F-27	F-28	F-29	F-30	Mean	S.D.	C.V.
			Animal Number					
Measured								
Dry Fat-Free Body Mass, g	74.44	81.16	75.28	72.30	77.39	76.11	3.36	4.4
Nitrogen, mmol/g DFFBM	8.92	8.81	8.71	8.76	9.02	8.84	0.13	1.4
Body Nitrogen, g	9.30	10.02	9.19	8.87	9.78	9.43	0.46	4.9
Calcium, mmol/g DFFBM	0.979	0.978	0.944	0.950	0.833	0.937	0.060	6.4
Body Calcium, g	2.92	3.18	2.85	2.75	2.58	2.86	0.22	7.8
Phosphorus, mmol/g DFFBM	0.875	0.869	0.874	0.846	0.749	0.843	0.054	6.4
Body Phosphorus, g	2.017	2.184	2.038	1.894	1.795	1.986	0.148	7.5
Potassium, mmol/g DFFBM	0.303	0.294	0.323	0.294	0.307	0.304	0.012	3.9
Body Potassium, g	0.882	0.933	0.951	0.831	0.929	0.905	0.049	5.4
Sodium, mmol/g DFFBM	0.1673	0.1607	0.1675	0.1625	0.1720	0.1660	0.0045	2.7
Body Sodium, g	0.286	0.300	0.290	0.270	0.306	0.290	0.014	4.8
Magnesium, mmol/g DFFBM	0.0635	0.0621	0.0630	0.0634	0.0605	0.0625	0.0012	2.0
Body Magnesium, g	0.1149	0.1225	0.1153	0.1114	0.1138	0.1156	0.0042	3.6
Creatine, mmol/g DFFBM	0.0733	0.0667	0.0692	0.0687	0.0695	0.0695	0.0024	3.5
Body Creatine, g	0.716	0.710	0.683	0.651	0.705	0.693	0.027	3.8
Derived								
Body Protein, g	58.13	62.63	57.44	55.44	61.13	58.95	2.90	4.9
Body Cell Mass, g	201.10	212.72	216.83	189.47	211.81	206.39	11.10	5.4
Intracellular Water Mass, g	146.80	155.29	158.29	138.31	154.62	150.66	8.10	5.4
Extracellular Water Mass, g	47.31	54.24	32.81	47.07	42.93	44.87	7.87	17.5
Bone Mineral Mass, g	8.56	9.32	8.35	8.06	7.56	8.37	0.65	7.8

Table 25. Body composition parameters measured or derived by analysis of the dry, fat-free body powder from the 5 Synchronous Control rats of Experiment K-316.

Parameter	S-26	S-27	S-28	S-29	S-30	Mean	S.D.	C.V.
	Animal Number							
Measured								
Dry Fat-Free Body Mass, g	77.96	83.52	76.74	76.87	78.92	78.80	2.78	3.5
Nitrogen, mmol/g DFFBM	8.78	8.61	8.91	8.49	8.84	8.73	0.17	2.0
Body Nitrogen, g	9.59	10.07	9.58	9.14	9.77	9.63	0.34	3.5
Calcium, mmol/g DFFBM	1.207	1.284	1.139	1.101	1.071	1.160	0.086	7.4
Body Calcium, g	3.77	4.30	3.50	3.39	3.39	3.67	0.38	10.5
Phosphorus, mmol/g DFFBM	0.941	1.088	0.893	0.902	0.865	0.938	0.088	9.4
Body Phosphorus, g	2.272	2.814	2.122	2.147	2.114	2.294	0.298	13.0
Potassium, mmol/g DFFBM	0.271	0.286	0.270	0.267	0.262	0.271	0.009	3.3
Body Potassium, g	0.826	0.934	0.810	0.802	0.808	0.836	0.055	6.6
Sodium, mmol/g DFFBM	0.1797	0.1775	0.1829	0.1790	0.1844	0.1807	0.0029	1.6
Body Sodium, g	0.322	0.341	0.323	0.316	0.335	0.327	0.010	3.1
Magnesium, mmol/g DFFBM	0.0663	0.0690	0.0591	0.0582	0.0571	0.0619	0.0053	8.6
Body Magnesium, g	0.1257	0.1401	0.1103	0.1088	0.1095	0.1189	0.0138	11.6
Creatine, mmol/g DFFBM	0.0611	0.0548	0.0613	0.0660	0.0627	0.0612	0.0041	6.7
Body Creatine, g	0.625	0.600	0.617	0.665	0.649	0.631	0.026	4.1
Derived								
Body Protein, g	59.94	62.94	59.88	57.13	61.06	60.19	2.11	3.5
Body Cell Mass, g	188.33	212.95	184.68	182.86	184.22	190.61	12.65	6.6
Intracellular Water Mass, g	137.48	155.45	134.82	133.49	134.48	139.15	9.23	6.6
Extracellular Water Mass, g	71.61	62.75	73.54	68.97	75.15	70.40	4.86	6.9
Bone Mineral Mass, g	11.05	12.60	10.26	9.93	9.93	10.75	1.13	10.5

Table 26. Body composition parameters measured or derived by analysis of the dry, fat-free body powder from the 5 Vivarium Control Rats of Experiment K-316.

Parameter	V-26	V-27	V-28	V-29	V-30	Mean	S.D.	C.V.
	Animal Number							
Measured								
Dry Fat-Free Body Mass, g	87.89	81.30	80.04	84.47	79.76	82.69	3.45	4.2
Nitrogen, mmol/g DFFBM	8.90	8.63	9.12	8.98	9.10	8.95	0.20	2.2
Body Nitrogen, g	10.96	9.83	10.23	10.63	10.17	10.36	0.44	4.2
Calcium, mmol/g DFFBM	1.092	1.393	1.097	1.262	1.137	1.196	0.130	10.8
Body Calcium, g	3.85	4.54	3.52	4.27	3.63	3.96	0.43	10.9
Phosphorus, mmol/g DFFBM	0.867	1.071	0.892	0.961	0.913	0.941	0.081	8.6
Body Phosphorus, g	2.360	2.697	2.211	2.514	2.255	2.407	0.200	8.3
Potassium, mmol/g DFFBM	0.284	0.267	0.301	0.297	0.268	0.283	0.016	5.6
Body Potassium, g	0.976	0.849	0.942	0.981	0.836	0.917	0.070	7.6
Sodium, mmol/g DFFBM	0.1743	0.1734	0.1712	0.1819	0.1737	0.1749	0.0041	2.3
Body Sodium, g	0.352	0.324	0.315	0.353	0.319	0.333	0.018	5.5
Magnesium, mmol/g DFFBM	0.0667	0.0730	0.0678	0.0704	0.0690	0.0694	0.0024	3.5
Body Magnesium, g	0.1425	0.1443	0.1319	0.1446	0.1338	0.1394	0.0061	4.4
Creatine, mmol/g DFFBM	0.0661	0.0639	0.0688	0.0643	0.0708	0.0668	0.0030	4.4
Body Creatine, g	0.762	0.681	0.722	0.712	0.741	0.724	0.031	4.2
Derived								
Body Protein, g	68.50	61.44	63.94	66.44	63.56	64.78	2.74	4.2
Body Cell Mass, g	222.53	193.57	214.78	223.67	190.61	209.03	15.87	7.6
Intracellular Water Mass, g	162.45	141.31	156.79	163.28	139.15	152.60	11.59	7.6
Extracellular Water Mass, g	69.09	75.31	59.10	64.52	79.47	69.50	8.16	11.7
Bone Mineral Mass, g	11.28	13.30	10.31	12.51	10.64	11.61	1.27	10.9

Table 27. Body constituent mean gram mass differences between the 5 Flight rats and the 5 Synchronous Control rats of Experiment K-316.

Constituent	Flight Mean (g)	Flight C.V.	Synchronous Mean (g)	Synchronous C.V.	Difference Col. 2 - Col. 4 (g)	Difference (%)	P
Body Nitrogen	9.43	4.9	9.63	3.5	- 0.20	- 2.1	0.46
Body Calcium ↓	2.86	7.8	3.67	10.5	- 0.81	-22.2	0.003
Body Phosphorus	1.986	7.5	2.294	13.0	- 0.308	-13.4	0.072
Body Potassium	0.905	5.4	0.836	6.6	+ 0.069	+ 8.3	0.069
Body Sodium ↓	0.290	4.8	0.327	3.1	- 0.037	-11.3	0.001
Body Magnesium	0.1156	3.6	0.1189	11.6	- 0.0033	- 2.8	0.62
Body Creatine ↑	0.693	3.8	0.631	4.1	+ 0.062	+ 9.8	0.006
Body Protein	58.95	4.9	60.19	3.5	- 1.24	- 2.1	0.46
Body Cell Mass	206.39	5.4	190.61	6.6	+15.78	+ 8.3	0.069
Intracellular Water	150.66	5.4	139.15	6.6	+11.51	+ 8.3	0.069
Extracellular Water ↓	44.87	17.5	70.40	6.9	-25.53	-36.3	<.001
Bone Mineral ↓	8.37	7.8	10.75	10.5	- 2.38	-22.2	0.003

Table 28. Body constituent mean gram mass differences between the 5 Flight rats and the 5 Vivarium Control rats of Experiment K-316.

Constituent		Flight Mean (g)	Flight C.V.	Vivarium Mean (g)	Vivarium C.V.	Difference Col. 2 - Col. 4 (g)	Difference (%)	P
Body Nitrogen	↓	9.43	4.9	10.36	4.2	- 0.93	- 9.0	0.011
Body Calcium	↓	2.86	7.8	3.96	10.9	- 1.10	-27.9	<.001
Body Phosphorus	↓	1.986	7.5	2.407	8.3	- 0.421	-17.5	0.005
Body Potassium		0.905	5.4	0.917	7.6	- 0.012	- 1.3	0.77
Body Sodium	↓	0.290	4.8	0.333	5.5	- 0.043	-12.7	0.004
Body Magnesium	↓	0.1156	3.6	0.1394	4.4	- 0.0238	-17.1	<.001
Body Creatine		0.693	3.8	0.724	4.2	- 0.031	- 4.2	0.13
Body Protein	↓	58.95	4.9	64.78	4.2	- 5.83	- 9.0	0.011
Body Cell Mass		206.39	5.4	209.03	7.6	- 2.64	- 1.3	0.77
Intracellular Water		150.66	5.4	152.60	7.6	- 1.94	- 1.3	0.77
Extracellular Water		44.87	17.5	69.50	11.7	-24.63	-35.4	0.001
Bone Mineral		8.37	7.8	11.61	10.9	- 3.24	-27.9	<.001

Table 29. Body constituent mean gram mass differences between the 5 Synchronous Control rats and the 5 Vivarium Control rats of Experiment K-316.

Constituent		Synchronous Mean (g)	C.V.	Vivarium Mean (g)	C.V.	Difference Col. 2 - Col. 4 (g)	(%)	P
Body Nitrogen	↓	9.63	3.5	10.36	4.2	- 0.73	- 7.1	0.018
Body Calcium		3.67	10.5	3.96	10.9	- 0.29	- 7.4	0.29
Body Phosphorus		2.294	13.0	2.407	8.3	- 0.113	- 4.7	0.50
Body Potassium		0.836	6.6	0.917	7.6	- 0.081	- 8.8	0.077
Body Sodium		0.327	3.1	0.333	5.5	- 0.006	- 1.6	0.60
Body Magnesium	↓	0.1189	11.6	0.1394	4.4	- 0.0205	-14.7	0.016
Body Creatine	↓	0.631	4.1	0.724	4.2	- 0.093	-12.8	<.001
Body Protein	↓	60.19	3.5	64.78	4.2	- 4.59	- 7.1	0.018
Body Cell Mass		190.61	6.6	209.03	7.6	-18.42	- 8.8	0.077
Intracellular Water		139.15	6.6	152.60	7.6	-13.45	- 8.8	0.077
Extracellular Water		70.40	6.9	69.50	11.7	+ 0.90	+ 1.3	0.84
Bone Mineral		10.75	10.5	11.61	10.9	- 0.86	- 7.4	0.29

Table 30. Per cent composition (g/100 g) of the fat-free body mass for the 5 Flight rats of Experiment K-316.

Constituent	F-26	F-27	F-28	F-29	F-30	Mean	S.D.	C.V.
	Animal Number							
Water	72.3	72.1	71.7	71.9	71.9	72.0	0.2	0.3
Dry Matter	27.7	27.9	28.3	28.1	28.1	28.0	0.2	0,8
Total	100.0	100.0	100.0	100.0	100.0	100.0		
Nitrogen	3.46	3.45	3.45	3.44	3.56	3.47	0.05	1.4
Calcium	1.087	1.094	1.070	1.067	0.938	1.051	0.064	6.1
Phosphorus	0.751	0.751	0.765	0.735	0.653	0.731	0.045	6.1
Potassium	0.328	0.321	0.357	0.322	0.338	0.333	0.015	4.5
Sodium	0.1065	0.1032	0.1089	0.1048	0.1113	0.1069	0.0032	3.0
Magnesium	0.0428	0.0421	0.0433	0.0432	0.0414	0.0426	0.0008	1.9
Creatine	0.267	0.244	0.256	0.253	0.2[illegible]	0.255	0.008	3.2
Protein	21.6	21.5	21.6	21.5	22.2	21.7	0.3	1.4
Body Cells	74.9	73.2	81.4	73.5	77.0	76.0	3.4	4.4
Intracellular Water	54.7	53.4	59.4	53.7	56.2	55.5	2.4	4.4
Extracellular Water	17.6	18.7	12.3	18.3	15.6	16.5	2.6	16.0
Bone Mineral	3.19	3.21	3.13	3.13	2.75	3.08	0.19	6.1
Fat-Free Body Mass, g	268.55	290.69	266.38	257.68	274.94	271.65	12.31	4.5

Table 31. Per cent composition (g/100 g) of the fat-free body mass for the 5 Synchronous Control rats of Experiment K-316.

Constituent	Animal Number S-26	S-27	S-28	S-29	S-30	Mean	S.D.	C.V.
Water	72.8	72.3	73.1	72.5	72.6	72.7	0.3	0.4
Dry Matter	27.2	27.7	26.9	27.5	27.4	27.3	0.3	1.1
Total	100.0	100.0	100.0	100.0	100.0	100.0		
Nitrogen	3.34	3.34	3.36	3.27	3.39	3.34	0.04	1.3
Calcium	1.313	1.425	1.228	1.214	1.175	1.271	0.100	7.8
Phosphorus	0.791	0.933	0.744	0.769	0.733	0.794	0.081	10.2
Potassium	0.288	0.310	0.284	0.287	0.280	0.290	0.012	4.0
Sodium	0.1122	0.1130	0.1133	0.1131	0.1161	0.1135	0.0015	1.3
Magnesium	0.0438	0.0464	0.0387	0.0390	0.0379	0.0412	0.0037	9.1
Creatine	0.218	0.199	0.216	0.238	0.225	0.219	0.014	6.5
Protein	20.9	20.9	21.0	20.5	21.2	20.9	0.3	1.2
Body Cells	65.6	70.6	64.8	65.5	63.8	66.1	2.6	4.0
Intracellular Water	47.9	51.5	47.3	47.8	46.6	48.2	1.9	3.9
Extracellular Water	24.9	20.8	25.8	24.7	26.0	24.4	2.1	8.6
Bone Mineral	3.85	4.18	3.60	3.55	3.44	3.72	0.30	7.9
Fat-Free Body Mass, g	287.05	301.72	285.10	279.33	288.55	288.35	8.25	2.9

Table 32. Per cent composition (g/100 g) of the fat-free body mass for the 5 Vivarium Control rats of Experiment K-316.

Constituent	Animal Number V-26	V-27	V-28	V-29	V-30	Mean	S.D.	C.V.
Water	72.5	72.7	73.0	72.9	73.3	72.9	0.3	0.4
Dry Matter	27.5	27.3	27.0	27.1	26.7	27.1	0.3	1.1
Total	100.0	100.0	100.0	100.0	100.0	100.0		
Nitrogen	3.43	3.30	3.46	3.40	3.41	3.40	0.06	1.8
Calcium	1.205	1.524	1.189	1.367	1.217	1.300	0.144	11.1
Phosphorus	0.739	0.905	0.747	0.805	0.756	0.790	0.069	8.7
Potassium	0.306	0.285	0.318	0.314	0.280	0.301	0.017	5.7
Sodium	0.1102	0.1088	0.1064	0.1130	0.1069	0.1091	0.0027	2.5
Magnesium	0.0446	0.0484	0.0446	0.0463	0.0448	0.0457	0.0016	3.6
Creatine	0.239	0.229	0.244	0.228	0.248	0.238	0.009	3.7
Protein	21.4	20.6	21.6	21.3	21.3	21.2	0.4	1.8
Body Cells	69.7	65.0	72.6	71.6	63.9	68.6	3.9	5.7
Intracellular Water	50.9	47.4	53.0	52.3	46.6	50.0	2.9	5.8
Extracellular Water	21.6	25.3	20.0	20.7	26.6	22.8	2.9	12.8
Bone Mineral	3.53	4.46	3.48	4.01	3.57	3.81	0.42	11.0
Fat-Free Body Mass, g	319.43	297.92	295.93	312.27	298.38	304.79	10.45	3.4

Table 33. Mean differences in per cent composition of the fat-free body mass between the 5 Flight rats and the 5 Synchronous Control rats of Experiment K-316.

Constituent		Flight Mean	Flight C.V.	Synchronous Mean	Synchronous C.V.	Difference Col. 2 - Col. 4 Mean	Difference Col. 2 - Col. 4 %	P
Water	↓	72.0	0.3	72.7	0.4	-0.7	- 0.9	0.004
Dry Matter	↑	28.0	0.8	27.3	1.1	+0.7	+ 2.5	0.004
Nitrogen	↑	3.47	1.4	3.34	1.3	+0.13	+ 4.0	0.002
Calcium	↓	1.051	6.1	1.271	7.8	-0.220	-17.3	0.003
Phosphorus		0.731	6.1	0.794	10.2	-0.063	- 7.9	0.17
Potassium	↑	0.333	4.5	0.290	4.0	+0.043	+15.0	<.001
Sodium	↓	0.1069	3.0	0.1135	1.3	-0.0066	- 5.8	0.003
Magnesium		0.0426	1.9	0.0412	9.1	+0.0014	+ 3.4	0.44
Creatine	↑	0.255	3.2	0.219	6.5	+0.036	+16.4	0.001
Protein	↑	21.7	1.4	20.9	1.2	+0.8	+ 3.7	0.002
Body Cells	↑	76.0	4.4	66.1	4.0	+9.9	+15.0	<.001
Intracellular Water	↑	55.5	4.4	48.2	3.9	+7.3	+15.1	<.001
Extracellular Water	↓	16.5	16.0	24.4	8.6	-7.9	-32.5	<.001
Bone Mineral	↓	3.08	6.1	3.72	7.9	-0.64	-17.2	0.003

Table 34. Mean differences in per cent composition of the fat-free body mass between the 5 Flight rats and the 5 Vivarium Control rats of Experiment K-316.

Constituent		Flight Mean	Flight C.V.	Vivarium Mean	Vivarium C.V.	Difference Col. 2 - Col. 4 Mean	Difference Col. 2 - Col. 4 %	P
Water	↓	72.0	0.3	72.9	0.4	-0.9	- 1.2	<.001
Dry Matter	↑	28.0	0.8	27.1	1.1	+0.9	+ 3.3	<.001
Nitrogen		3.47	1.4	3.40	1.8	+0.07	+ 2.1	0.074
Calcium	↓	1.051	6.1	1.300	11.1	-0.249	-19.2	0.008
Phosphorus		0.731	6.1	0.790	8.7	-0.059	- 7.5	0.15
Potassium	↑	0.333	4.5	0.301	5.7	+0.032	+10.8	0.013
Sodium		0.1069	3.0	0.1091	2.5	-0.0022	- 1.9	0.29
Magnesium	↓	0.0426	1.9	0.0457	3.6	-0.0031	- 7.0	0.005
Creatine	↑	0.255	3.2	0.238	3.7	+0.017	+ 7.4	0.012
Protein		21.7	1.4	21.2	1.8	+0.5	+ 2.1	0.074
Body Cells	↑	76.0	4.4	68.6	5.7	+7.4	+10.9	0.012
Intracellular Water	↑	55.5	4.4	50.0	5.8	+5.5	+10.9	0.012
Extracellular Water	↓	16.5	16.0	22.8	12.8	-6.3	-27.8	0.007
Bone Mineral	↓	3.08	6.1	3.81	11.0	-0.73	-19.1	0.008

Table 35. Mean differences in per cent composition of the fat-free body mass between the 5 Synchronous Control rats and the 5 Vivarium Control rats of Experiment K-316.

Constituent		Synchronous Mean	Synchronous C.V.	Vivarium Mean	Vivarium C.V.	Difference Col. 2 - Col. 4 Mean	Difference Col. 2 - Col. 4 %	P
Water		72.7	0.4	72.9	0.4	-0.2	- 0.3	0.29
Dry Matter		27.3	1.1	27.1	1.1	+0.2	+ 0.8	0.29
Nitrogen		3.34	1.3	3.40	1.8	-0.06	- 1.8	0.11
Calcium		1.271	7.8	1.300	11.1	-0.029	- 2.3	0.72
Phosphorus		0.794	10.2	0.790	8.7	+0.004	+ 0.5	0.94
Potassium		0.290	4.0	0.301	5.7	-0.011	- 3.6	0.28
Sodium	↑	0.1135	1.3	0.1091	2.5	+0.0044	+ 4.1	0.011
Magnesium	↓	0.0412	9.1	0.0457	3.6	-0.0045	-10.0	0.036
Creatine	↓	0.219	6.5	0.238	3.7	-0.019	- 7.7	0.040
Protein		20.9	1.2	21.2	1.8	-0.3	- 1.6	0.13
Body Cells		66.1	4.0	68.6	5.7	-2.5	- 3.6	0.27
Intracellular Water		48.2	3.9	50.0	5.8	-1.8	- 3.6	0.27
Extracellular Water		24.4	8.6	22.8	12.8	+1.6	+ 7.0	0.35
Bone Mineral		3.72	7.9	3.81	11.0	-0.09	- 2.3	0.72

Table 36. Water and dry matter composition of the digestive tract contents for the 5 Flight rats, the 5 Synchronous Control rats, and the 5 Vivarium Control rats of Experiment K-316.

Parameter	F-26	F-27	F-28	F-29	F-30	Mean	S.D.	C.V.
	Animal Number							
Flight Rats								
Wet Mass, g	8.26	15.07	10.19	8.74	6.24	9.70	3.32	34.2
Dry Mass, g	1.73	4.41	2.78	1.94	1.33	2.44	1.22	50.2
Water Mass, g	6.53	10.66	7.41	6.80	4.91	7.26	2.11	29.1
% Water	79.1	70.7	72.7	77.8	78.7	75.8	3.8	5.1
% Dry Matter	20.9	29.3	27.3	22.2	21.3	24.2	3.8	15.9

	S-26	S-27	S-28	S-29	S-30	Mean	S.D.	C.V.
Synchronous Control Rats								
Wet Mass, g	6.05	14.48	4.89	3.90	7.01	7.27	4.20	57.8
Dry Mass, g	1.19	3.65	1.00	0.87	1.21	1.59	1.16	73.4
Water Mass, g	4.86	10.83	3.89	3.03	5.80	5.68	3.06	53.8
% Water	80.3	74.8	79.6	77.7	82.7	79.0	3.0	3.7
% Dry Matter	19.7	25.2	20.4	22.3	17.3	21.0	3.0	14.1

	V-26	V-27	V-28	V-29	V-30	Mean	S.D.	C.V.
Vivarium Control Rats								
Wet Mass, g	6.78	6.61	4.27	5.21	5.83	5.74	1.04	18.0
Dry Mass, g	1.22	1.13	0.77	1.05	1.03	1.04	0.17	16.2
Water Mass, g	5.56	5.48	3.50	4.16	4.80	4.70	0.88	18.7
% Water	82.0	82.9	82.0	79.8	82.3	81.8	1.2	1.4
% Dry Water	18.0	17.1	18.0	20.2	17.7	18.2	1.2	6.5

Table 37. Statistical significance of the differences in means of the water and dry matter composition of the digestive tract contents between the 5 Flight rats, the 5 Synchronous Control rats, and the 5 Vivarium Control rats of Experiment K-316.

Parameter		Flight Mean	Flight C.V.	Synchronous Mean	Synchronous C.V.	Difference Col. 2 - Col. 4 Mean	Difference Col. 2 - Col. 4 %	P
Wet Mass, g		9.70	34.2	7.27	57.8	+2.43	+33.5	0.34
Dry Mass, g		2.44	50.2	1.59	73.4	+0.85	+53.9	0.29
Water Mass, g		7.26	29.1	5.68	53.8	+1.58	+27.8	0.37
% Water		75.8	5.1	79.0	3.7	-3.2	- 4.1	0.18
% Dry Matter		24.2	15.9	21.0	14.1	+3.2	+15.3	0.18

Parameter		Flight Mean	Flight C.V.	Vivarium Mean	Vivarium C.V.	Difference Col. 2 - Col. 4 Mean	Difference Col. 2 - Col. 4 %	P
Wet Mass, g	↑	9.70	34.2	5.74	18.0	+3.96	+69.0	0.034
Dry Mass, g	↑	2.44	50.2	1.04	16.2	+1.40	+134.4	0.035
Water Mass, g	↑	7.26	29.1	4.70	18.7	+2.56	+54.5	0.037
% Water	↓	75.8	5.1	81.8	1.4	-6.0	- 7.3	0.010
% Dry Matter	↑	24.2	15.9	18.2	6.5	+6.0	+33.0	0.010

Parameter		Synchronous Mean	Synchronous C.V.	Vivarium Mean	Vivarium C.V.	Difference Col. 2 - Col. 4 Mean	Difference Col. 2 - Col. 4 C.V.	P
Wet Mass, g		7.27	57.8	5.74	18.0	+1.53	+26.6	0.45
Dry Mass, g		1.59	73.4	1.04	16.2	+0.55	+52.3	0.33
Water Mass, g		5.68	53.8	4.70	18.7	+0.98	+20.9	0.51
% Water		79.0	3.7	81.8	1.4	-2.8	- 3.4	0.087
% Dry Matter		21.0	14.1	18.2	6.5	+2.8	+15.3	0.087